June 21, - December 21, 1907.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

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VOLUME XXXV.

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VOL. V, 1872.

Part 1.—Annual report for 1871. Rough section showing the relations of the rocks near Murree (Mari), Punjab. Mineralogical notes on the gneiss of South Mirzapur and adjoining country. Description of the sandstones in the neighbourhood of the first barrier on the Godavari, and in the country between the Godavari and Ellore.

Part 2.—On the geological formation seen along the coasts of Beluchistan and Persia from Karachi to the head of the Persian Gulf, and on some of the Gulf Islands. On a traverse of parts of the Kummummet and Hanamconda districts in the Nizam's Dominions. The geology of Orissa. On a new coal-field in the south-eastern part of the Hyderabad (Deccan) territory.

Part 3.—On Maskat and Massandim on the east coast of Arabia. An example of local jointing. On the axial group of Western Prome. On the geology of the Bombay Presidency.

Part 4.—On exploration for coal in the northern region of the Satpura basin. On the value of the evidence afforded by raised oyster banks on the coasts of India, in estimating the amount of elevation indicated thereby. On a possible field of coal-measures in the Godavari district, Madras Presidency. On the lameta or infra-trappean formation of Central India. On some recently discovered petroleum localities in Pegu. Correction regarding the supposed eozoonal limestone of Yellam Bile.

VOL. VI, 1873.

Part 1.—Annual report for 1872. The geology of the North-West Provinces.

Part 2.—The Bisrampur coal-field. Mineralogical notes on the gneiss of South Mirzapur and adjoining country.

Part 3.—Notes on a celt found by Mr. Hacket in the ossiferous deposits of Narbada valley (Pliocene of Falconer): on the age of the deposits, and on the associated shells. On the Barakars (coal-measures) in the Beddadanole field, Godavari district. On the geology of parts of the Upper Punjab. Coal in India. The salt-springs of Pegu.

Part 4.—On some of the iron deposits of Chanda (Central Provinces). Barren Islands, and Narkondam. Stray notes on the metalliferous resources of British Burma.

VOL. VII, 1874.

Part 1.—Annual report for 1873. On the geological structure of the hill ranges between the Indus valley in Ladak and Shah-i-Dula on the frontier of Yarkand territory. On some of the iron ores of Kumaon. On the raw materials for iron-smelting in the Raniganj field. On the habitat in India of the elastic sandstone, or so-called Itacolumyte. Geological notes on part of Northern Hazaribagh (*out of print*).

Part 2.—Geological notes on the route traversed by the Yarkand Embassy from Shah-i-Dula to Yarkand and Kashgar. On the occurrence of jade in the Karakas valley, on the southern borders of Turkistan. Notes from the Eastern Himálaya. Petroleum in Assam. Coal in the Garo Hills. On the discovery of a new locality for copper in the Narbada valley. Potash-salt from East India. On the Geology of the neighbourhood of Mari hill station in the Punjab.

Part 3.—Geological observations made on a visit to the Chaderkul, Thian Shan range. On the former extension of glaciers within the Kangra district. On the building and ornamental stones of India. Second note on the materials for iron manufacture in the Raniganj coal-field. Manganese ore in the Wardha coal-field.

Part 4.—The auriferous rocks of the Dhambal hills, Dharwar district. Remarks on certain considerations adduced by Falconer in support of the antiquity of the human race in India. Geological notes made on a visit to the coal recently discovered in the country of the Luni Pathans, south-east corner of Afghanistan. Note on the progress of geological investigation in the Godavari district, Madras Presidency. Notes upon the subsidiary materials for artificial fuel (*out of print*).

Vol. VIII, 1875.

Part 1.—Annual report for 1874. The Altum-Artush considered from a geological point of view. On the evidences of 'ground-ice' in tropical India, during the Talchir period. Trials of Raniganj fire-bricks.

Part 2. (out of print).—On the gold-fields of south-east Wynaad, Madras Presidency. Geological notes on the Khareean hills in the Upper Punjab. On water-bearing strata of the Surat district. Sketch of the geology of Scindia's territories.

Part 3.—The Shahpur coal-field, with notice of coal explorations in the Narbada region. Note on coal recently found near Moflong, Khasia Hills.

Part 4.—Note on the geology of Nepal. The Raigarh and Hingir coal-fields (*out of print*).

Vol. IX, 1876.

Part 1.—Annual report for 1875. On the geology of Sind (*out of print*).

Part 2.—The retirement of Dr. Oldham. On the age of some fossil floras in India. Description of a cranium of Stegodon Ganesa, with notes on the sub-genus and allied forms. Note upon the Sub-Himalayan series in the Jamu (Jummoo) Hills.

Part 3.—On the age of some fossil floras in India. On the geological age of certain groups comprised in the Gondwana series of India, and on the evidence they afford of distinct zoological and botanical terrestrial regions in ancient epochs. On the relations of the fossiliferous strata at Maleri and Kota, near Sironcha, C. P. On the fossil mammalian faunæ of India and Burma.

Part 4.—On the age of some fossil floras in India. On the osteology of Merycopotamus dissimilis. Addenda and Corrigenda to paper on tertiary mammalia. Occurrence of Plesiosaurus in India. On the geology of the Pir Panjal and neighbouring districts.

Vol. X, 1877.

Part 1.—Annual report for 1876. Geological notes on the Great Indian Desert between Sind and Rajputana. On the occurrence of the cretaceous genus Omphalia near Nameho lake, Tibet, about 75 miles north of Lhassa. On Estheria in the Gondwana formation. Notices of new and other vertebrata from Indian tertiary and secondary rocks. Description of a new Emydine from the upper tertiaries of the Northern Punjab. Observations on under-ground temperature.

Part 2.—On the rocks of the Lower Godavari. On the 'Atgarh Sandstones' near Cuttack. On fossil floras in India. Notices of new or rare mammals from the Siwaliks. On the Arvali series in North-eastern Rajputana. Borings for coal in India. On the geology of India.

Part 3.—On the tertiary zone and underlying rocks in the North-west Punjab. On fossil floras in India. On the occurrence of erratics in the Potwar. On recent coal explorations in the Darjiling district. Limestones in the neighbourhood of Barakar. On some forms of blowing-machine used by the smiths of Upper Assam. Analyses of Raniganj coals.

Part 4.—On the Geology of the Mahanadi basin and its vicinity. On the diamonds, gold, and lead ores of the Sambalpur district. Note on 'Eryon Comp. Barrovensis,' McCoy, from the Sripermatur group near Madras. On fossil floras in India. The Blaini group and the 'Central Gneiss' in the Simla Himálayas. Remarks on some statements in Mr. Wynne's paper on the tertiaries of the North-west Punjab. Note on the general Chæromeryx and Rhagatherium.

Vol. XI, 1878.

Part 1.—Annual report for 1877. On the geology of the Upper Godavari basin, between the river Wardha and the Godavari, near the civil station of Sironcha. On the geology of Kashmir, Kishtwar, and Pangi. Notices of Siwalik mammals. The palæontological relations of the Gondwana system. On 'Remarks, &c., by Mr. Theobald upon erratics in the Punjab.'

Part 2.—On the Geology of Sind (second notice). On the origin of the Kumaun lakes. On a trip over the Milam Pass, Kumaun. The mud volcanoes of Ramri and Cheduba. On the mineral resources of Ramri, Cheduba and the adjacent islands.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1907. [April.

GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR THE YEAR 1906. BY T. H. HOLLAND, F.R.S., *Director*.

CONTENTS.

INTRODUCTION.

THE great development of interest in Indian mineral deposits, as shown by the remarkable increase in the applications for concessions reported by the Local Governments, has had an effect also on the office work of this Department, and the duty of answering enquiries, instead of being a mere addition to the work of the officers at head-quarters, as was formerly the case, now consumes the largest fraction of our time. Although many of the enquiries are of a kind that are fully covered by the publications of the Department, and do not consequently warrant further explanation, some of them open up new lines for research; but in apportioning our available time between the distribution of information and the development of further data by research work, the former at present obtains more than its fair share. Most of the officers at head-quarters have taken a part in the work of assisting enquirers, but the principal part of the burden, in addition to editing the *Records* and *Memoirs*, has fallen on Mr. Hayden, who has been Superintendent in charge of the office for most of the year, and as this duty does not appear in the publications of the Department it deserves special notice in this review of the year's work.

DISPOSITION LIST.

2. During the period under report the officers of the Department were employed as follows:—

Superintendents.

Mr. Tom D. La Touche .	Returned from Burma on the 16th April 1906. Deputed to the Northern Shan States, Burma, with special reference to the Geology of Bawdwingyi and the auriferous tracts between Lashio and the Salween river, and left for the field on the 16th November 1906.
Mr. C. S. Middlemiss .	Returned from the field on the 25th March 1906. On leave from 25th May 1906 to the 17th November 1906. At head-quarters preparing report on the Kángra earthquake.

Mr. H. H. Hayden .	At head-quarters in charge of office up to 14th August 1906. Deputed to Kashmir on 15th August 1906, in connection with the secular movement of glaciers; returned to head-quarters on the 8th November 1906, and resumed charge of the office.

Assistant Superintendents.

Mr. P. N. Datta . .	Returned from the Central Provinces on the 26th April 1906, and deputed to the same area for continuation of the Geological Survey of the Bhandara district on the 2nd November 1906.
Mr. E. Vredenburg .	Returned from Baluchistan on the 19th April 1906. Appointed Palæontologist with effect from 7th August.
Mr. L. L. Fermor . .	At head-quarters as Curator. Posted to the Central Provinces from 3rd to 20th December 1906, in connection with the manganese investigation.
Mr. G. E. Pilgrim . .	At head-quarters as Palæontologist. Granted 3 months' privilege leave and 9 months' study leave in continuation, with effect from 7th August 1906.
Mr. G. H. Tipper . .	Returned from Baluchistan on the 28th June 1906. Deputed to the North-West Frontier Province for the survey of unmapped areas, and left for the field on the 10th November 1906.
Mr. H. Walker . .	Returned to head-quarters from the field on the 4th May 1906. Deputed to Lahaul and Spiti in connection with the secular movement of glaciers on the 9th August, 1906, returning on the 12th October 1906. Posted to the Central Provinces and Central India for the mapping of unsurveyed areas, and left for the field on the 18th November 1906.

Mr. E. H. Pascoe . .	Returned from Burma on the 24th May 1906. Deputed to Lahaul and Spiti in connection with the secular movement of glaciers and left head-quarters on the 10th August 1906, returning on the 12th October. Re-posted to Burma in connection with the petroleum industry, and left for the field on the 13th November 1906.
Mr. K. A. K. Hallowes .	Returned from Chota Nagpur on the 29th May 1906. Re-posted to the Singhbhum district for continuation of the investigation of the copper-sulphide deposits, and left for the field on the 1st December 1906.
Mr. G. deP. Cotter . .	Returned from the field on the 4th May 1906. Deputed to Kumaon in connection with the secular movement of glaciers and left head-quarters on the 7th June, returning on the 8th November 1906. Posted to Burma under Mr. Pascoe for work in connection with oil industry, and left head-quarters for the field on the 25th November 1906.
Mr. J. Coggin Brown .	At head-quarters. Deputed to Kumaon in connection with the secular movement of glaciers on the 7th June returning on the 8th November 1906. Posted to Burma with Mr. La Touche's party and left for the field on the 4th December 1906.
Mr. J. J. A. Page . .	Joined the Department on the 27th December 1906.
Mr. H. C. Jones . .	Joined the Department on the 2nd December 1906.
Mr. A. M. Heron . .	Joined the Department on the 27th December 1906.

Mining Specialists.

Mr. R. R. Simpson . .	Returned from Assam on the 28th March 1906. Transferred to the Mines Department on the 1st May 1906.
Mr. J. M. Maclaren . .	Returned to head-quarters on the 7th June 1906. Resigned his appointment on the 9th October 1906.

Chemist.

Mr. W. A. K. Christie .	Joined the Department on the 17th November 1906. At head-quarters.

Sub-Assistants.

S. Sethu Rama Rau .	Returned from the field on the 7th May 1906. Deputed to Southern India for duty and left on the 9th August 1906, returning to head-quarters on the 25th October 1906. Posted to the Indore State, Central India, and left for the field on the 6th December 1906.
M. Vinayak Rao . .	Returned to head-quarters from Sind on the 20th December 1906. At head-quarters.

Assistant Curator.

Mr. T. R. Blyth . .	On duty at head-quarters. On privilege leave from 6th August 1906 to 21st September 1906.

ADMINISTRATIVE CHANGES.

3. The following officers joined the Department during the period under report:—

New Appointments .	Mr. W. A. K. Christie, B.Sc., Ph.D., joined the service on the 17th November 1906.
	Mr. H. C. Jones, A.R.S.M., A.R.C.S., F.G.S., joined on the 2nd December 1906.

New Appointments—*contd.*	Mr. J. J. A. Page, A.R.S.M., Assoc. Inst. M.M., joined on the 27th December 1906.
	Mr. A. M. Heron, B.Sc. (Edin.), joined on the 27th December 1906.
Officiating Appointments .	Mr. Tom D. La Touche, appointed to officiate as Director during the absence of Mr. T. H. Holland with effect from the forenoon of the 12th May 1906.
	Mr. P. N. Datta, appointed to officiate as Superintendent with effect from the 12th May 1906, *vice* Mr. T. D. La Touche.
	Mr. E. Vredenburg, appointed to officiate as Superintendent with effect from the 25th May 1906, *vice* Mr. C. S. Middlemiss.
	Mr. E. Vredenburg was appointed Palæontologist, *vice* Mr. G. E. Pilgrim, with effect from the 7th August 1906.
Transfer . .	Mr. R. R. Simpson was transferred to the Mines Department with effect from the 1st May 1906.
Resignation . . .	Mr. J. M. Maclaren resigned his appointment with effect from the 9th October 1906.
Leave . .	Mr. T. H. Holland, Director, was on privilege leave and special duty from the 12th May to the 29th September 1906.
	Mr. C. S. Middlemiss was granted privilege leave and furlough from the 25th May to the 17th November 1906.

Leave—*contd.* . .	Mr. G. E. Pilgrim was granted 3 months' privilege leave and 9 months' study leave in continuation, with effect from the 7th August 1906.
	Mr. T. R. Blyth was granted privilege leave from the 6th August to 21st September 1906.
Sub-Assistants . .	S. Sethu Rama Rau was confirmed in his appointment as Sub-Assistant with effect from the 11th February 1904.
	M. Vinayak Rao was confirmed in his appointment as Sub-Assistant with effect from the 26th October 1904.

Reorganization of the Department.

4. With effect from the 1st July 1906, the Right Honourable the Secretary of State has sanctioned an increase in the graded list of gazetted officers, and the creation of a special post of Chemist. The two ungraded temporary posts for Mining Specialists have been abolished in order to permit of the entertainment of officers with a knowledge of mining on the graded list qualifying for the usual pension and promotion to the administrative posts. Of the two last holders of the temporary posts of Mining Specialist, Mr. R. R. Simpson was appointed to be an Inspector of Mines on the 1st May, and Mr. J. M. Maclaren, having given six months' notice of his intention to resign, was permitted to retain his appointment under the old conditions until his departure on the 9th October.

Study leave.

5. The Secretary of State has also sanctioned the grant of an extra year of furlough with a special allowance, counting as service towards pension, for officers of the Geological Survey to undergo courses of study in Europe between their third and eighteenth years of service.

PUBLICATIONS.

Records.

6. The following parts of the *Records* were published during the year, containing the following papers and notes:—

Volume XXXIII.

Volume XXXIV.

The Classification of the Tertiary System in Sind with reference to the Zonal Distribution of the Eocene Echinoidea described by Duncan and Sladen, by E. Vredenburg, A.R.C.S.

The Jaipur and Nazira Coal-fields, Upper Assam, by R. R. Simpson, B.Sc.

Note on the Makum Coal-field between the Tirap and Namdang Streams, by R. R. Simpson, B.Sc.

The Kabat Anticline, near Seiktein, Myingyan District, Upper Burma, by E. H. Pascoe M.A., B.Sc.

The Asymmetry of the Yenangyat-Singu Anticline, Upper Burma, by E. H. Pascoe, M.A., B.Sc.

The Northern part of the Gwegyo Anticline, Myingyan District, Upper Burma, by E. H. Pascoe, M.A., B.Sc.

Breynia multituberculata, an undescribed species from the Nari of Baluchistan and Sind, by E. Vredenburg, A.R.S.M., A.R.C.S.

Miscellaneous Notes :—

On samples of mud from Narrakal, Allepy and Calicut at the smooth water anchorages on the Travancore Coast.

Note on a boring in the Tertiary deposits of Mayurbhanj.

Preliminary note on the Trias of Lower Burma.

Note on the Tertiary deposits of Mayurbhanj.

On the use of Gypsum for the recovery of Ammonia as a bye-product in Coke-making.

Index to Volume XXXIV.

Memoirs.

The following two Memoirs were published during the year :—

Fauna of the Tropites-Limestone of Byans, by Professor Carl Diener, Ph.D., *Palæontologia Indica*, Series XV, Volume V, Memoir No. 1.

The Lower Palæozoic Fossils of the Northern Shan States, Burma, by F. R. Cowper Reed, M.A., F.G.S., *Palæontologia Indica*, New Series, Volume II, Memoir No. 3.

MUSEUM AND LABORATORY.

Staff.

7. Mr. L. L. Fermor has been in charge as Curator throughout the year, and principally through his untiring energy we have been able to keep pace with the rapidly growing work of this section. As usual, Mr. Blyth, the

Assistant Curator, continued to give valuable help both in the Museum and Laboratory work, although his time at the office was shortened by the necessity of taking some privilege leave owing to ill health caused by his work in the Laboratory.

Determinative and chemical work.

8. The number of specimens and samples of minerals, ores, rocks, and fossils, referred to the Curator by the general public, extra-departmental officials, and officers in the field, slightly exceeded the number examined in 1905, being 786 as compared with 782 in that year. Of this total 87 required quantitative assay or analysis. In addition to these, however, two large collections were received from provincial museums for determination. Of the collection received from the Nagpur Museum, 512 specimens of fossils, besides a large number of minute fossil shells, and 18 specimens of minerals, were determined. For the Lahore Museum, 244 specimens of minerals and rocks and a large number of fossils were named and labelled. In carrying out this additional work the Curator received considerable help from the then Palæontologist, Mr. G. E. Pilgrim, and from Mr. J. Coggin Brown. In addition to the assays and analyses above mentioned, considerable progress has been made in the estimation of the amount of silt and total salts in the samples of Indus river water collected by Sub-Assistant M. M. Ry. Vinayak Rao. The following is the number of determinations made :—

Collecting station.	Silt.	Dissolved salts.
Sukkur	287	84
Kotri	228	51

There are now 142 samples remaining undetermined.

9. Dr. W. A. K. Christie, who took up the newly created post of Chemist on the 17th November, commenced with a chemical examination of the Sambhar Lake brines. His results will be published in a memoir now in the press, detailing the results of this enquiry which has been referred to briefly in previous General Reports.

Apprentices.

10. The apprentice sent by the Director of Agriculture, United Provinces, towards the end of 1905, worked in the Geological Laboratory and Museum up to May 23rd, 1906, and gained an insight into the ways of determining minerals, both physical and chemical, and into the methods of arranging and classifying specimens in a geological museum. Two students were also deputed by the Travancore Durbar for training in the Laboratory and field; one has devoted a portion of his time to field work in Nellore and Chota Nagpur, while the other has been attached to the Central Indian party.

Meteorites.

11. No meteorites are recorded as having fallen in India during 1906. Mention was made in the General Report for 1905[1] of a fragment weighing 32·4 lbs. of an aërolite obtained near Karkh in that year. Additional fragments since obtained bring the total weight up to 21,735 grammes or 48 lbs. One of these has been obtained by Mr. E. Vredenburg from the Native Assistant, Jhalawán, and the remainder from Major H. L. Showers, Political Agent, Kalat, through the Second Assistant to the Honourable the Agent to the Governor-General in Baluchistan. Portions of the Dokáchi fall have been presented to His Royal Highness Prince Edward of York, the British Museum, the K. K. Naturhistorisches Hofmuseum, Vienna, and the Museum d'Histoire Naturelle, Paris. On the other hand, donations have been received of portions of four rare Indian meteorites, namely, Bhágur (or Dhulia, 2·5 grammes), Jamkhair (1·7 grammes), and Pirganj (16·2 grammes), from the British Museum, and Kalambi (11·0 grammes) from the Vienna Museum. A slice of the Estocado meteorite has been obtained by exchange.

With these additions the number of meteoric falls represented in the Geological Museum has now reached a total of 393, comprising 148 siderites (and siderolites) and 245 aërolites, of which totals 2 and 68 respectively are Indian. The only known Indian falls now unrepresented in our collection are Bherai, Chail, and Gurram Konda, Kángra.

Two papers have been prepared by Mr. Fermor describing the most recent of the Indian meteoric falls. Both will be published in *Records*, Vol. XXXV, one on the Dokáchi stones, and the other dealing with the Haraiya, Delhi, Karkh and Bholgháti falls. The Dokáchi

[1] *Rec. Geol. Surv. Ind.*, XXXIII, p. 72.

fall is one of unusual interest on account of the number of observations made regarding the track of the meteor, which was seen over most of Bengal and Assam and probably much beyond these provinces. Altogether 24 fragments have been collected by the Geological Survey, ranging in weight from 1,571 to 0·73 grammes, and these were obtained along a band running west by south from Bibandi in the Dacca district to near the east bank of the Ganges at Kolapára, a distance of 6 miles, the larger fragments having fallen near the western end of the line towards which the meteor was travelling when disruption occurred. The fragments are nearly all covered with a crust, and on some of the faces of the smaller fragments the formation of a younger crust shows the fusion that occurred after disruption.

The Museum.

12. The Economic Mineral collection has now been completely re-labelled and all the cases and specimens cleaned up. In the Palæontological gallery collections have been arranged in the show cases illustrating the Jurassic corals and echinoids of Cutch, the Jurassic fossils of Balúchistán, the Trias of the Himálaya, the Permo-Carboniferous fossils of Chitichun and other places in the Himálaya, the Cambrian of the Salt Range and the Miocene and Palæozoic of Burma. The following presentations to the Museum, in addition to those noticed in the section on meteorites, are worthy of special mention :—

1. Crystals of braunite and numerous specimens of hollandite, from the Kájlidongri mine, Jhábua State, Central India; by H. J. Winch.
2. Crystals of braunite from the Lohdongri manganese mine, Nágpur district, Central Provinces, by Mr. W. H. Clark.
3. Many specimens of rhodonite from the Mánegáon manganese mine, Nágpur district, Central Provinces; by Mr. H. D. Coggan.
4. Specimens of the manganese-ores and associated rocks of the manganese mines, Queluz district, Brazil; by Mr. H. Kilburn Scott.
5. Nine small diamonds from Ramallakota, Karnul district, Madras; by Mr. H. S. Colville.
6. Eighteen articles of glass ware and semi-porcelain manufactured by the Himálaya Glass Works, Limited, Rájpur, Dehra Dun.

7. Specimens of glendonite from New South Wales; glaciated pebbles from the Permo-Carboniferous beds of Tasmania, and some igneous rocks from Tasmania; presented by Professor T. W. Edgeworth David, F.R.S.

13. During 1906 many rare minerals were acquired by exchange. The following is a list:—

Allactite; Nordmark, Sweden.
Anneródite; Anneröd, Norway.
Ardennite; Salm Château, Belgium.
Arseniopleite; Sjö mine, Sweden.
Atopite; Minas Geraes, Brazil.
Bementite; Franklin Furnace, New Jersey, United States of America.
Berzeliite; Långban mine, Sweden.
Bixbyite; Western Utah, United States of America.
Brandtite; Harstig mine, Sweden.
Caswellite; Franklin Furnace, New Jersey.
Chalcophanite; Sterling Hill, New Jersey.
Childrenite; Tavistock, Devon, England.
Dumortierite; Clip, Yuma Co., Arizona, United States.
Elpidite; Narsasuk, Greenland.
Friedelite; Adervielle, Hautes Pyrénées, France.
Gummite; Mitchell Co., North Carolina, United States.
Hauerite; Raddusa, Sicily.
Inesite; Jacobsberg, Sweden.
Kentrolite; Långban mine, Sweden.
Kunzite; Pala, California, United States.
Långbanite; Långban mine.
Rinkite; Naujakasik, Greenland.
Roepperite; Broken Hill, New South Wales.
Sarkinite; Harstig mine.
Sussexite; Franklin Furnace, New Jersey.
Thorogummite; Llano Co., Texas, United States.
Uranophane; Mitchell Co., North Carolina.

14. In addition to the donations of meteorites made to foreign museums, as enumerated on page 12, the following collections have been presented by the Geological Survey:—

1. One hundred and fourteen specimens of minerals and rocks,

5 metallurgical objects, and 2 fossiliferous nodules; to His Royal Highness Prince Edward of York.

2. Sixty-four specimens of minerals and rocks to the Mayurbhanj State Museum.
3. Fourteen specimens of typical Indian manganese minerals and ores to the mining division of the Civil Engineering College, Sibpur.
4. A collection of various rocks and minerals to the University of Sydney, through Professor Edgeworth David, F.R.S., in exchange for those mentioned on page 14.

A special visit was made by Sub-Assistant S. Sethu Rama Rau to the Madras Presidency, where he made large collections from the typical exposures of the following series:—

1. The Charnockite series.
2. The Sivamalai series of elæolite-syenites and corundum-syenites of the Coimbatore district.
3. The rocks of the neighbourhood of Salem.

These specimens have been collected to permit of exchange with other institutions from which numerous such requests have been received.

LIBRARY.

15. The additions to the Library during the period 1st January 1906 to 31st December 1906 amounted to 2,991 volumes. Of the books received this year 1,017 were acquired by purchase and 1,974 by presentation.

PALÆONTOLOGY.

Palæontologist: Mr. G. E. Pilgrim.

16. Mr. G. E. Pilgrim continued to act as Palæontologist until the 7th August, when he was granted leave for study at the Cambridge University and the British Museum. Before taking leave he was occupied mainly with the study of the fossil collections made in the Persian Gulf region during the season 1904-05. Since leaving India he has submitted a description of a specimen of *Boselaphus namadicus* Rütimeyer from the older alluvium of the Narbada valley. The specimen was obtained from the Nágpur Museum, and is now preserved in the Survey collection at Calcutta.

Palæontologist: Mr. E. Vredenburg.

17. Mr. E. Vredenburg was appointed Palæontologist on the 7th August 1906, and, in addition to the routine work of the office, has been able to summarise the results of his study of our Lower Tertiary collections. In continuation of his work on the Foraminifera referred to in the last Annual Report,[1] Mr. Vredenburg has paid special attention to the distribution of the foraminiferal genera *Orthophragmina* and *Lepidocyclina* in view of the doubts which have been expressed as to their constant separation in European Tertiary strata. So far no instance has been found in India of these two genera in association with one another: *Lepidocyclina* has never been found below the Nari (oligocene), while *Orthophragmina* has never been found above the lower zones of the Upper Khirthar (eocene). Thus so far as the Indian Tertiaries are concerned, these two genera retain the stratigraphical value which has been claimed for them, especially by Douvillé, as distinctive of the eocene and oligocene, and their complete separation tends to accentuate the value of the break between these two series.

Tertiary Foraminifera.

18. Reference was made in the Annual Report for 1905[2] to the occurrence of a new species of nummulite among the Lower Tertiary Foraminifera of India. This species has now been described in detail by Mr. Vredenburg as *N. Douvillei*,[3] which is associated in Cutch with its near relative, *N. lævigatus*, and other nummulites characteristic of the Middle Khirthar (Lutetian) horizon in Sind. As there will be some unavoidable delay in the publication of Mr. Vredenburg's full memoir on the India nummulites, he has appended to his paper on *N. Douvillei* a summary of his results with regard to the zonal distribution of the Lower Tertiary Foraminifera, which may now be correlated with his later work on the Echinoidea of Western India.[4]

Classification of Tertiary strata.

19. The most striking conclusion of stratigraphical value to be drawn from this work is the great importance of the breaks between most of the stages: in the Balúchistán area, where the beds are more disturbed, the unconformities are obvious from the stratigraphical evidence, while in Sind, where the only serious orogenic movements

[1] *Rec. Geol. Surv. Ind.*, XXXIII, 77, 1906.
[2] *Rec. Geol. Surv. Ind.*, XXXIII, 77, 1906.
[3] *Rec. Geol. Surv. Ind.*, XXXIV, 79, 1906.
[4] *Rec. Geol. Surv. Ind.*, XXXIV, 173, 1906.

occurred in late Tertiary times, there is a general physical parallelism among the Lower Tertiary strata, but the interruptions in deposition are, according to Mr. Vredenburg, none the less pronounced when the palæontological evidence is sifted. Of these breaks the most important is that which occurs at the base of the Tertiary system separating it from the *Cardita Beaumonti* beds, which are placed by Mr. Vredenburg as low as the Maestrichtian, and thus separating the uppermost Cretaceous beds of Western India from the lowermost Tertiary by a gap occupied by the Thanetian and Montian stages in Europe. Similar breaks are recognised between the Ranikot and Laki, the name now used for a stage formerly included with the Khirthar, from which, however, it is separated by a distinct break corresponding to the Middle or Lower Lutetian of Europe. The Khirthar is also separated from the Lower Nari by a break corresponding approximately to the Bartonian stage. In Sind, where there is no noticeable stratigraphical discordance between the stages, lateritic bands between two superimposed sets of beds indicate the existence of continental conditions without changes of elevation sufficient to disturb the general parallelism of the strata above and below.

20. As a result of his re-examination of our Tertiary materials, Mr. Vredenburg notices that the eocene beds have a much greater importance than either of the younger sub-divisions to which an equivalent series value has been given. There is a more marked general change at the commencement than the end of the oligocene, and it is at this point that the line should be drawn between Lower and Upper Tertiary. The data in India accentuate the evidence recently accumulated elsewhere to show that the base of the oligocene is a main line of classification among the Tertiary strata: there is a conspicuous stratigraphical as well as a faunistic break between the eocene Khirthar and oligocene Nari, but a much closer connection between the latter and the overlying Gáj, while the calcareous beds of the Gáj (Upper Aquitanian) pass gradually into the Hingláj sandstones of Burdigalian (Lower Miocene) age, after which a break occurs before the establishment of the Manchhar (Siwalik) strata.

Echinoidea.

21. A species of Desor's echinoid genus *Breynia*, discovered by Mr. Vredenburg in the Nari beds of the Pishin district in Balúchistán, proves to be unusually interesting. It shows that *Breynia* existed in oligocene times in a form closely related to the abundant and characteristic Gáj species

B. carinata, and to a species still living in the Indian Ocean, which has recently been described by Major A. R. S. Anderson, I.M.S., under the name *B. Vredenburgi*. The Nari species has been described by Mr. Vredenburg in a special paper in *Records*, Vol. XXXIV, part 4, under the name *B. multituberculata*. An account of the stratigraphical distribution of the Echinoidea described by Duncan and Sladen has been published as a separate paper in *Records*, Vol. XXXIV, page 173. Mr. Vredenburg's palæontological work at head-quarters, in conjunction with the field observations made during past years in Sind and Balúchistán, has thus resulted in the establishment of data of the highest value for classifying our numerous complicated and sometimes apparently contradictory records regarding the exceptionally fine development of Tertiary beds in India.

Mr. G. H. Tipper: Triassic fossils in the Arakan Yoma.

22. An examination of the fossils collected in the Arakan Yoma by Mr. W. Theobald forty years ago, and left unregistered in the Museum, has been made by Mr. G. H. Tipper, who has thereby removed the doubt that has existed for some time as to the occurrence of Triassic beds in Theobald's Axial group.[1] Mr. Tipper has recognised among Theobald's collections species of *Halobia*, *Monotis*, and *Avicula* closely related to known Triassic forms, and has thus confirmed the existence of Triassic rocks in the Arakan area of Lower Burma (*Rec. Geol. Surv. Ind.*, XXXIV, 1906, 134). But it is evident that the so-called Axial group includes more than Triassic rocks, for Mr. Tipper has also recognised, among Theobald's collections from the supposed Triassic strata, the characteristic *Cardita Beaumonti* d'Arch., so well known in Sind and Balúchistán, where this form is abundant in beds regarded by Vredenburg as Upper Cretaceous (Maestrichtian to Lower Danian) in age. The Axial group in the Arakan Yoma thus promises a field of very great geological interest when it is possible to attack the area systematically.

Rotalia in Mayurbhanj limestones.

23. Mr. Tipper has also examined the Foraminifera found among some deposits in Mayurbhanj and determined before as *Amphistegina*.[2] Mr. Tipper has not confirmed the presence of *Amphistegina* in these

[1] *Manual, Geol. Ind.*, 2nd Ed., p. 145, f. n.; *Rec. Geol. Surv. Ind.*, XXVI, 1893, 9.

[2] *Rec. Geol. Surv. Ind.*, XXXIV, p. 42.

deposits, but has found many specimens of *Rotalia* related to *R. obicularis* d'Orb., which, on account of its long geological range, has no precise stratigraphical value, and the age of the Mayurbhanj deposits thus remains doubtful.[1]

Northern Shan States: Devonian fossils.

24. Mr. F. R. Cowper Reed has completed an examination of the Devonian fossils colleeted by the Geological Survey officers in the Northern Shan States and his results will be published as a special memoir in the *Palæontologia Indica* (New Series, Vol. II, Memoir No. 5). The two localities from which most of the fossils were obtained afford no evidence as to the stratigraphical relationships between the rocks in which they occur and the prevalent limestone formations of the plateau, from other parts of which *Fusulina* and other Permo-Carboniferous forms have been obtained (*cf.* p. 52). The rich fauna from Padaukpyin (22° 6′ ; 96° 40′) includes an abundance of corals, bryozoa, and brachiopods associated with a very small number of representatives of crinoids, molluscs, and trilobites. The general assemblage suggests physical and bionomical conditions similar to those that prevailed during the formation of the limestones of the Eifel district in Germany, where corals and brachiopods also predominate among the Devonian forms. The species represented show stronger affinity with the forms known in the Calceola stage in Europe than with other Lower Middle Devonian occurrences, the well-known species *Calceola sandalina* being specially abundant. Mr. Reed has also pointed out the relations between the rich coral fauna of Padaukpyin and the forms known in other Devonian occurrences in Asia, America, and Australia, thus adding further evidence to show the wide effects of the transgression of the Middle Devonian sea.

25. Although the Devonian age of the shales at Wetwin (22° 6′; 96° 38′) is beyond doubt, the fossils described by Mr. Reed are distinct from those of Padaukpyin, and instead of resembling the European fauna they include many species related to or identical with those of the Hamilton series in North America. No stratigraphical data have been obtained in the Northern Shan States to determine the relative ages of the Wetwin shales and the Padaukpyin limestones, but

[1] *Rec. Geol. Surv. Ind.*, XXXIV, 135.

the general palæontological facies indicates a slightly younger age for the former. As the fauna of the Zebingyi beds[1] of Lower Devonian or uppermost Silurian age is essentially European with no trace of American elements, and the Padaukpyin fauna shows only small traces of connection with the American seas, the displacement of European by American influences when the Wetwin shales were formed may be accepted as in agreement with the other evidences which indicate that the Wetwin shales belong to a slightly higher horizon in the Devonian than the Padaukpyin limestones.

Central Himálayas: Triassic fossils.

26. Professor Carl Diener has completed his description of the large collections of Muschelkalk fossils collected by various officers of the Geological Survey in the Central Himálayas of Spiti and Kumaon. His work, issued as a special memoir in the *Palæontologia Indica*,[2] supplements the descriptions previously published of older collections by himself,[3] A. Bittner,[4] and von Krafft.[5]

27. The evidence now carefully sifted shows that there is a striking similarity between the Himálayan and the Alpine Muschelkalk. The upper beds are especially rich in Brachiopoda, while in the lower beds Cephalopoda predominate, and these rest conformably on beds that correspond with the thick unfossiliferous limestone below the *Binodosus* zone of the Eastern Alps. Among the cephalopods now described twelve species are either closely related to, or identical with, those previously known in the Alpine Muschelkalk, while three characteristic species of brachiopods are common to both areas. The *Ceratites* are the most abundant among the cephalopods, both in number and variety, being represented by 10 sub-genera and 41 species, while the genera *Ptychites*, *Gymnites*, and *Beyrichites* are also very rich in forms. Of the cephalopods generally as many as 148 species, belonging to 41 genera and sub-genera, are now known in the Himálayan Muschelkalk. Professor Diener has shown that the additional material now described indicates a less close relationship

[1] *Cf. Rec. Geol. Surv. Ind.*, Vol. XXXIII, p. 75.
[2] Ser. XV, Vol. V, Memoir No. 2 (1906).
[3] *Pal. Ind.*, Ser. XV, Vol. II, part 2, 1895.
[4] *Ibid.*, Vol. III, part 2, 1900.
[5] General Report, Geol. Surv. Ind., 1898-99, pp. 11-22.

between the Triassic faunas of the Arctic-Pacific and the Himálayan regions than between the latter and the Alpine province.

PETROLOGY.

Vizagapatam district: Sapphirine-bearing rocks.

28. Dr. T. L. Walker, formerly Assistant Superintendent in this Department and now Professor of Mineralogy and Petrology in the Toronto University, has kindly made a detailed study, in conjunction with Mr. W. H. Collins of the Canadian Geological Survey, of the sapphirine-bearing rocks discovered by Mr. C. S. Middlemiss during the season 1902-03 in the Vizagapatam district.[1] The author's paper, which will be published in a later part of the *Records*, confirms Mr. Middlemiss' conclusion as to the similarity between the petrological association of sapphirine in India and the single previously known occurrence at Fiskernäs in Greenland. Messrs. Walker and Collins regard the rocks as the result of the mingling and subsequent metamorphism of ultra-basic borders of the charnockite series and the highly aluminous para-schists rich in sillimanite belonging to Walker's khondalite series. Some of the rock-types containing cordierite appear to be new to petrography, while a form of pyroxene has been detected having the pleochroism of hypersthene, but with inclined extinction; for this variety the name clino-hypersthene is suggested.

Nepheline-syenites.

29. Professor Walker has also furnished us with a description of the nepheline-syenites discovered by Mr. Middlemiss near Koraput in the same district. The prevalent types approach the miaskite of the Urals in mineralogical composition, biotite predominating over hornblende among the ferromanganese silicates. There is also a close agreement with some of the nepheline-bearing rocks previously described from the Coimbatore district in general composition and in the presence of calcite as a primary constituent.[2] Judging by the previously known associations of this class in South India, Ontario, and Montana, one would be justified in searching hopefully for corundum deposits in their neighbourhood in Vizagapatam.

[1] *Rec. Geol. Surv. Ind.*, XXXI, 1904, 38.

[2] Holland: The Sivamalai series of Elæolite-syenites and Corundum-syenites, *Mem. Geol. Surv. Ind.*, XXX, 169, 1901.

Manganese-bearing rocks.

30. Mr. Fermor has continued the study of the materials associated with the various manganese-ore bodies, and has found an extraordinarily large number of new varieties of previously known mineral species. In the Vizagapatam district these manganese-bearing crystalline rocks appear to form a distinct facies among the previously known series. The groups hitherto recognised in this area are—

1. The charnockite series.
2. The khondalite series.
3. The contact products of 1 and 2.
4. The gneissose granites.

From among the miscellaneous types forming the unclassified residue, Mr. Fermor proposes to separate the manganese intrusive rocks. The typical rock of this series is composed of potash-felspar, manganese-garnet, and apatite. The common form when fresh is granular in structure and of a texture resembling a medium-grained granite, but it sometimes assumes a pegmatitic form. This type of rock being apparently new, Mr. Fermor proposes to distinguish it by the name ***kodurite***, after the Kodur manganese mine where it is well exposed. The varieties containing quartz will be known as quartz-kodurite, those containing pyroxene, as pyroxene-kodurite, and the rare variety containing biotite, as biotite-kodurite.

Kodurite.

Those rocks consisting entirely of manganese-pyroxenes will be distinguished as manganese-pyroxenites. The garnet is intermediate in composition between spessartite and andradite, and to avoid the frequent repetition of the indefinite phrase "manganese-garnet," Mr. Fermor proposes to introduce the term spessart-andradite, which may be shortened for convenience in general use to ***spandite***. This name may be used for any garnet intermediate in composition between andradite and spessartite and not sufficiently close to either in composition to merit either of those names. Similar hybrid terms could be conveniently introduced to designate the other varieties of garnets which happen to be intermediate between two of the standard forms and not very close to either.

Kodurite series.

31. The whole of this series of manganese intrusives may be conveniently known as the ***kodurite series***, the term kodurite, when not followed by the word "series," and when not in any way qualified by prefixing the name of

any mineral, being understood to mean the rock composed almost entirely of the three minerals—spandite, potash-felspar, and apatite. The terminology thus adopted follows that employed for the charnockite series (*Mem. Geol. Surv. Ind.*, XXVIII, part 2), the term being of local value only, indicating the existence of a definite petrographical province.

PHYSICAL GEOLOGY.

Himálayan glaciers.

32. In 1905, Mr. D. W. Freshfield, on behalf of the *Commission International des Glaciers*, drew the attention of Lieutenant-Colonel S. G. Burrard, F.R.S., Superintendent of Trigonometrical Surveys, to the importance of recording data for determining the secular movements of the principal Himálayan glaciers. As the work required the co-operation of all officers and private travellers likely to visit the glacier regions of the Himálaya, Colonel Burrard referred the question to the Board of Scientific Advice, and, on the recommendation of a sub-committee composed of Colonel F. B. Longe, R.E., Surveyor-General, Dr. G. T. Walker, F.R.S., and myself, the Board agreed on a system of observations, recommending that the distribution of the necessary information and collection of data should be under the control of the Geological Survey Department. The proposals having received the sanction of the Government of India, the first step in the investigation was taken by the deputation of five Geological Survey officers during August and September to make a preliminary survey of the principal glaciers in the Kumaon, Lahaul, and Kashmir regions. Altogether twelve glaciers were examined, as follows:—

Kumaon.—The Pindari, Milam, Shunkulpa, and Poting glaciers were examined by Messrs. G. deP. Cotter and J. C. Brown.

Lahaul.—The Bara Shigri and Sonapani glaciers were examined by Messrs. H. Walker and E. H. Pascoe.

Kashmir Region.—The Barche and Hinarche glaciers in the Bagrot valley, the Minapin, Hispar, and Yengutsa glaciers in the Nagir state, and the Hassanabad glacier in Hunza were examined by Mr. H. H. Hayden.

33. Of all these glaciers plane-table sketches were made, showing the exact positions of the ice-caves with reference to points fixed on rocks in the valleys, as well as with reference to prominent and

unmistakable peaks in the vicinity. Photographs were taken from various points of view carefully marked on the map and described in the reports, showing the state of the glaciers and the principal masses of moraine material at the time of the visit. These photographs will enable subsequent travellers to form an idea of any changes that may have occurred in the interval, and will thus make the observations of value even if the fixed points cut in the rocks are destroyed by weathering or by being overwhelmed with loose material. As the available time was very limited, the officers devoted their energies mainly towards fixing these essential points instead of making detailed examinations of the ice, the included dirt-bands and certain other features of general interest in connection with glacier movement. A certain number of such observations have, however, been recorded in the reports. Arrangements are now in progress for reproducing the plane-table sketches and the most important amongst the photographs to illustrate the reports, which will be published as one paper divisible into three sections for transmission to the district officers or travellers in the three regions.

34. The first point that strikes one on examination of the reports is the fact that the glaciers of the Hunza valley and the Karakoram range generally descend to lower altitudes than in the Lahaul and Kumaon regions. In the former region the snouts of the glaciers proceed down to levels of 7,000 or 8,000 feet, while in the latter region they melt before descending below the level of about 11,000 feet. In the Hunza region, also, there are two classes of glaciers :—

(*a*) Those which flow transversely to the trend of the mountain range, and are relatively short, with a steep descent reaching down to elevations as low as 8,000 feet and under, and

(*b*) those which lie in troughs parallel to the range, and also approximately parallel to the strike of the rocks of which the range is composed. These, having at their angles of slope a less rapid fall, rarely descend below 10,000 feet.

The second point most prominently displayed is the evidence of general retreat shown by the occurrence in nearly all cases of old moraines (sometimes grass-covered) at lower levels in the valleys. This point does not, of course, necessarily mean that the glaciers are now in retreat, and two well-authenticated cases of recent advance have been found in the Yengutsa and Hassanabad glaciers. The valleys below the glaciers being generally covered by moraine material and talus from the hills around, very seldom reveal the solid rock, and consequently the evidence with regard to the erosive action of the ice is very unsatisfactory. Only two instances have been recorded of the solid basement rock being exposed and showing marks of glaciation, namely, the Shunkulpa glacier in Kumaon and the Minapin glacier in Nagir. These observations are insufficient to show whether the glaciers had eroded material in large quantity, or had only succeeded in striating and polishing the rocks over which they flowed. In the case of the Minapin glacier, the rock striated is a crystalline limestone, over which the glacier must have formed a considerable ice-fall, the rounded mass of rock being striated on the lee-side as well as above.

35. One of the most interesting features recorded in the reports is the occurrence of a large, dry lake-basin, about 1½ miles in length and nearly a mile in width, immediately below the Sonapani glacier. This was formed by the damming up of the glacier stream by an old terminal moraine. The waters of the lake have, since the silting of the basin, cut through the moraine barrier and escaped, leaving a desiccated plain along which meander numerous branches of the glacier stream.

River action.

36. In 1903, I drew the attention of the Board of Scientific Advice to the unsatisfactory nature of our information regarding the data available with regard to the amounts of silt and dissolved salts carried by the large Indian rivers to the sea, and, on the recommendation of the Board, Government sanctioned the institution of systematic investigations. Having the control of such great rivers as the Indus, Ganges, Brahmaputra, and Irrawaddi, and possessing a well-organized Department of Irrigation officers, the Indian Government should be in an unusually favourable situation for contributing data towards the solution of the denudation problem, which is of such immense interest to geologists. Estimates of the silt carried down have been made at various points of certain rivers which are utilised for irrigation in the Punjab; but the only figures obtainable for the suspended matter are confessedly rough estimates, made before satisfactory data were obtained, even for the water discharge, and obtained at points that do not give the total discharges into the sea or on to the deltaic tract. Among the few figures which have been published, special prominence has been given in text-books of

Physical Geology to the case of the Ganges since the publication of Sir Charles Lyell's 'Principles,' in which a graphic picture was drawn of successive fleets of eighty Indiamen, each freighted with 1,400 tons' weight of mud, sailing down the river every hour of the day and night, carrying a load no greater than that borne quietly by the silt-laden water of the Ganges during the monsoon.[1] The materials from which this fancy picture was drawn were obtained in 1831-32 by the Revd. R. Everest at Ghazipur, above the confluences of the Gogra, Gandak, Kosi, Son, and a number of smaller, but by no means small, rivers; and although this fact was noticed by Lyell, it has been generally overlooked by other authors, while no one has noticed the fact, clearly shown in Everest's two notes to the Asiatic Society of Bengal in 1832,[2] that the observations made as to the cross-section of the stream, its velocity and content in solid matter were assumed from a few rough measurements. No one probably would be more embarrassed than Everest if he had guessed that such far-reaching conclusions and fancy pictures would be drawn from his modestly recorded notes.

The Indus.

37. The problem of determining the amounts of silt and dissolved salts carried into the sea by the larger rivers of India was definitely attacked towards the end of 1905 by the deputation of Sub-Assistant M. Vinayak Rao to collect samples of the Indus river-water at Kotri (25° 22'; 68° 21'), where gauge-readings for the water-discharge have been maintained by the Public Works Department since 1864, and at Sukkur (27° 42'; 68° 55'), where the gauge-readings have been taken regularly since 1850. At Kotri two stations were chosen, samples being collected from the surface, mid-depth and bottom of the river at one station, and from the surface and bottom only at the other. At Sukkur, where the river is broader and not so deep, three stations were established, and samples were collected at the surface and bottom only. At all stations samples were collected once a week during the cold weather and twice a week during the inundation season. Altogether 739 samples were collected during the year November 22nd, 1905, to November 22nd, 1906, and these are now being examined in the Laboratory. The amount taken in each case filled a cylinder $6 \times 8 \times 2\frac{1}{2}$ inches, the apparatus being designed in its final form and set up to suit the

[1] Principles, 10th Ed., 1867, I, 481.
[2] *Journ. As. Soc. Beng.*, Vol. I, pp. 238 and 549.

practical difficulties at each station by M. Vinayak Rao, who deserves great credit for the systematic and thorough manner in which the work has been conducted. Before the issue of the next Annual Report we hope to be able to make a statement of the results of this first essay, and it is proposed, as soon as we have fairly gauged the weak spots in our system of collecting, to organize operations on a larger scale for the other large Indian rivers.

ECONOMIC ENQUIRIES.

General.

38. The Director was placed by the Secretary of State for India on special duty, in extension of his privilege leave, during 1906, in order to visit certain metallurgical and chemical works in England and Ireland. The chief object in view was the collection of information on special points bearing on Indian mineral products which have come into prominence during the last two years, and are believed to occur in quantities and under conditions "promising" for development. The observations made and the questions put to experts were arranged to give information that will assist in directing the researches of the Department with greater precision, permitting at the same time of more acurate judgment with regard to the industrial value of the facts collected for the preparation of the new edition of the Manual of Economic Geology. Data were obtained more especially with regard to the following points :—

(*a*) the suitablity of our recently discovered deposits of bauxite for the manufacture of pure alumina for export to aluminium smelting works;

(*b*) the utilisation of bye-products in coke-making;

(*c*) the ores suitable for the smelting of copper and the manufacture of copper-sulphate and sulphuric acid;

(*d*) the question of exporting the richer and purer ores of iron, and the manufacture of iron and steel in India;

(*e*) the comparison of Indian manganese-ores with those received from other parts of the world at the steel works in the north of England; and

(*f*) the question of manufacturing ferro-manganese and spiegeleisen in India.

A detailed report giving the information collected has been submitted confidentially to Government.

Arsenic.

39. During the course of their survey of the Shunkulpa glacier referred to on page 23, Messrs. Cotter and Brown discovered scattered fragments of orpiment and realgar lying on the moraine material about one mile above the ice-cave of the glacier (30° 19′; 80° 24′), near the north-west side of the valley. The minerals were confined to a limited area in the moraine, and had apparently not been moved far from their source, probably somewhere on the hill-face immediately above; but, owing to the freshly fallen snow on the hills and the general inaccessibility of the cliffs, the ore was not found *in situ*. Similar ores of arsenic have been reported before in this area from the neighbourhood of Munsiari[1] (30° 7′; 80° 18′), and the occurrence is worth further investigation when opportunity occurs.

Bauxite.

40. In 1905 a paper was published by this Department[2] giving the information then at our disposal as to the occurrences of highly aluminous laterites (bauxites) in India. Two of the samples from the Baihir tahsil, Bálághát district, were reported to be fairly representative of extensive deposits, and as both were found on analysis to contain over 50 per cent. of free alumina, larger samples collected by Mr. H. H. Hayden in January 1905, were forwarded in the following month to the Imperial Institute for more complete examination in the Scientific and Technical Department. A report, dated 10th December 1906, by Professor W. R. Dunstan, F.R.S., Director of the Institute, confirms our previous conclusion as to the high value of these bauxites; in fact, the analyses now reported show on an average a higher percentage of alumina than those previously obtained by this Department, the amounts ranging from 52 to nearly 59 per cent. Al_2O_3, with silica from 0·58 to 2·65 per cent. only. The Imperial Institute analyses also agree with those made by this Department in showing that in this area high proportions of titanium oxide

[1] *Rec. Geol. Surv. Ind.*, II, 88, 1869.
[2] Holland: The occurrence of bauxite in India, *Rec. Geol. Surv. Ind.*, XXXII 175.

occur in the bauxite, as much in one case as 13·76 per cent. TiO_2. One of the samples contained only 2·70 per cent. of ferric oxide, and might be used, consequently, for the preparation of aluminous salts as well as for the manufacture of pure alumina suitable for reduction to the metal. All the samples examined at the Institute come within the limits of bauxite marketable as a source of aluminium, and in this respect they compare favourably with the material now being mined so largely in the South of France. A test made during the past year on a large scale in one of the factories in Europe has shown that the Indian bauxite is suitable for the manufacture of the pure alumina by Bayer's process.

41. From the paper quoted and the General Report of this Department for 1903-04,[1] it will be seen that for use as a source of aluminium the Indian bauxites might be developed in three possible ways:—

(1) Simple export of the raw or calcined material to Europe or America for use in the alumina factories.

(2) Manufacture of pure alumina locally by extraction with alkali, and export of the pure oxide to European or American aluminium works.

(3) Manufacture of the metal in India.

The first proposal was considered to be impracticable on account of the low prices of raw bauxite at European ports, while the third proposal would involve a heavy capital outlay under untried conditions and an elaborate preliminary investigation before power works could be erected. The second proposal, therefore, involved smaller risks and appeared to be the one most practicable as a beginning in India: the process for preparing pure alumina by the use of caustic soda requires no heavy capital expenditure, and although the soda used would, in the first instance, be imported, most of that consumed can be recovered after separation of the aluminic hydrate, and the whole of it can be renewed locally. It has been objected, however, that the aluminic hydrate obtained by this chemical process from bauxite cannot be dehydrated in a form suitable for transport to the power works of Europe and America. This statement proves to be incorrect: the writer has seen the process in full work in Europe, the purified and dehydrated alumina being obtained by calcination of the

[1] *Rec. Geol. Surv. Ind.*, XXXII, 144.

hydrate in the form of a fine white flour, containing over 99 per cent. Al_2O_3, suitable for transport in sacks to any distance. In this form pure alumina is now being exported on a large scale from Europe to America for reduction to aluminium. There are thus no technical difficulties in the way of manufacturing alumina from the Indian bauxites, and it should be possible, when this first step has been accomplished, to establish reasonable grounds for the larger venture of utilising our cheap supplies of power for manufacturing the metal. We are satisfied now that the investigation instituted by the Geological Survey in 1903 has definitely proved the existence in India of bauxite that will compare favourably with that which is being worked on a large scale in Europe as a source of aluminium · the exploitation of our deposits offers therefore a promising field for private enterprise.

Building Stone and Road-metal.

42. The rapid development of Rangoon has resulted in a greatly increased local demand for road-metal and building stone, and attempts are being made, naturally, to utilise the local resources. With this in view Mr. J. Coggin Brown was deputed during December to examine the exposures of gneissose granite, east of the Sittang in the Pegu district, and his report shows the existence of a sufficient quantity of suitable material within three miles of the Sittang-Kyaikto canal and the new Pegu-Maulmain Railway. The chief objection to this area is the thick layer of laterite and detrital material that covers most of the granite; but in one place there is sufficient rock exposed to permit of the development of quarrying, with little or no overburden, over an area of 1,500 x 500 feet, and there are other exposures of fresh rock in the neighbourhood. Details have accordingly been supplied to the Local Government.

Coal.

Naga hills, Assam.

43. In 1864-65, Mr. H. B. Medlicott was deputed to make a general examination of the reported coal occurrences in Assam, including the Makum and Jaipur fields; but was unable, on account of the state of the tribes, to visit the Nazira area further south-west. On account of the superior quality of the thick coal in the vicinity of Makum, Mr. Medlicott recommended this area in preference to the Jaipur field for mining operations, although the latter area is more easily accessible from the

Brahmaputra, which was then the only possible traffic route and the principal market for coal.[1] As is well known, the Makum field has since been connected by a metre-gauge railway with the Brahmaputra at Dibrugarh, and for some years has been producing about a quarter of a million tons of coal per annum.

During 1874-75, Mr. F. R. Mallet accompanied two police expeditions through the Naga hills, and although his movements were necessarily limited in a country then hardly opened, he succeeded in studying some fields that were not reached by Mr. Medlicott.[2]

44. On account of the recent completion of the hill section of the Assam-Bengal Railway, passing through the Cachar district and near the north-western face of the Naga hills to join the Dibrugarh-Makum line, the coal deposits of the fields south-west of Makum assumed a new importance. In order to extend our information and to bring the facts into correlation with the changed economic conditions, Mr. R. R. Simpson was deputed to survey this area during the season 1905-06. His results have now been published in the *Records*.[3] The coal beds are described in two groups, namely, those of the area around Jaipur (27° 16′; 95° 26′) crossed by the Dehing and Disang rivers, and those further to the south-west, lying to the south-east of Nazira (26° 55′; 94° 47′). The coals belong to the same Tertiary series as those well known in the Makum field, which they resemble generally although of slightly inferior quality, with considerable local variations in physical characters and composition. The 38 assays made by Sub-Assistant Sethu Rama Rau show that they have a high average value as fuels, the chief drawbacks being the large percentage of sulphur, which reduces the value of the coals for coke-making, and a proportion of moisture which is high when compared with the Lower Gondwana coals of Bengal.

Mr. Simpson confirms the estimate made by Mr. Mallet with regard to the large quantity of good fuel in these two fields, and in addition to the estimates of coal that can be proved there is a probability of larger quantities hidden by the alluvial deposits; but in many places the seams are highly inclined, and, being below the level of permanent saturation, will be difficult to work except with special precautions to deal with the water. The exposures in the

[1] *Mem. Geol. Surv. Ind.*, IV, 397.

[2] *Mem. Geol. Surv. Ind.*, XII, part 2.

[3] Vol. XXXIV, part 4, 1906.

neighbourhood of the Dikhu river are selected by Mr. Simpson as offering the most promising mining proposition. Of the coal proved at this point 2½ million tons would be certainly obtainable, with good evidence as to the existence of much more. The rocks are less disturbed than in other areas, the dips varying from 20° to 35° only; and, in addition to the coal which is above free drainage level, much of that at lower levels could be added with little expense. The chief apparent drawback to this area is the difficult nature of a portion of the country between the coal outcrops and the railway, which lies some seven miles to the north-west; for this short stretch of broken ground, however, wire-rope transport could be economically arranged.

45. Mr. Simpson has also sampled the coal seams being worked in the Upper Ledo and Tikak mines of the Makum field. Assays of the samples, made by Sub-Assistant Sethu Rama Rau, and published in *Records*, Vol. XXXIV, part 4, confirm the general impression as to the high quality of fuel obtainable in this remarkable area. In the case of the middle coal of the Tikak colliery, 12 feet thick, the ash amounts to only 0·79 per cent., and the moisture to 2·33, leaving nearly 97 per cent. of combustible hydrocarbons, of which nearly 60 per cent. is fixed carbon. Allowing for the thickness sampled in each band, the coal in the Upper Ledo colliery, with an aggregate thickness of 49 feet, shows the following average composition calculated from the assays:—

Moisture	1·80	per cent.
Volatile hydrocarbons	40·15	„
Fixed carbon	55·59	„
Ash	2·46	
	100·00	

In the case of the Tikak colliery five samples, representing an aggregate thickness of 47 feet, give an average composition of:—

Moisture	2·09
Volatile hydrocarbons	37·25
Fixed carbons	58·99
Ash	1·67
	100·00

46. During their march through the Sub-Himálayan zone to the glacier region, Messrs. Cotter and Brown examined the newly exposed rocks in the road cuttings between Kotdwára and Lansdowne, chiefly with a view of checking reports received with regard to the occurrence of coal seams in the Siwalik rocks. Traces of coal were noticed between the first and the eighth milestones from Kotdwára, but the largest of these, occurring in the eighth mile, were mere lenticular patches a few inches long. The coal so occurring is known at innumerable places in this system of rocks in the Sub-Himálayan region, and, being often of good quality, gives rise frequently to reports of promising indications. The geological notes recorded on the new road agree with the general description and geological map of this area published by Mr. Middlemiss.[1]

Sub-Himalayas.

47. Mr. R. R. Simpson has placed on record[2] a note describing the circumstances under which the collieries at Warora in the Central Provinces were finally abandoned in 1906 after being worked by Government for 33 years.

Warora colliery.

Copper.

48. In 1903, attention was directed by this Department to the unsatisfactory state of our knowledge regarding the copper-ores of Chota Nágpur, about which published statements indicated the possible existence of pyritic ores that might be developed to meet our growing demand for sulphur as well as copper. The latest published description of these deposits is by Mr. R. Oates, who has given an account of the unsuccessful attempts made to work the copper-ore deposits near Rajdoha in the Singhbhum district and Baragunda in Hazaribagh.[3] The work done by the companies who have attempted mining operations near Amda, Rajdoha, and Rakka shows that the oxidised ores found near the outcrops pass into sulphides at comparatively small depths and that the lodes follow

Chota Nagpur.

[1] *Mem. Geol. Surv. Ind.*, XXIV, part 2. *Rec. Geol. Surv. Ind.*, XVIII, 73, and XX, 26 *et seq.*

[2] *Rec. Geol. Surv. Ind.*, XXXIV, 132.

[3] "The copper and tin deposits of Chota Nagpore, Bengal." *Trans. Fed. Inst. of Mining Engineers*, IX, 427 (1895).

the planes of schistosity of the country rocks, dipping at angles less than 50° from the horizon. It appeared likely, therefore, that the band might be tested conveniently by borings put down on the dip side of the outcrops. As the companies were either in liquidation or without sufficient funds, it was decided, in the absence of private venturers, that it would be in the interests of the public to obtain further data with regard to the belt by boring operations conducted at the expense of Government.

49. Accordingly, Mr. K. A. K. Hallowes was deputed during the field season 1905-06 to make a superficial survey of the belt in order to fix suitable sites for the borings, the first of which was commenced in January 1906 at Kodomdia, north of Amda, a station on the Bengal-Nagpur Railway. This boring having proved the persistence of the copper lodes to a depth of 400 feet, arrangements were made for a boring further north to test the existence of the ores to a depth of about 1,000 feet. This boring is still in progress, and another shallow drill has been undertaken further west on the copper belt near the village of Reghadih in the Kharsawan state. On the completion of these operations the data obtained will be published for general information.

It has been known for many years that a mineralised band stretches more or less continuously for a distance of about 80 miles from a little west of the Kharsawan state to the borders of Midnapore district and Mayurbhanj state.[1] At several points along this band ancient workings show that the superficial oxidised ores were largely excavated by native workers. As suggested by Dr. Ball (*loc. cit.*, p. 95) the copper-bearing band extends further to the west, and it has now been traced by Mr. Hallowes for some ten miles west of Lopso to the Bamini river near Duarparom (22° 45′; 85° 38′). The band lies near the apparent base of the rocks mapped by Ball as "Sub-Metamorphic" close to their junction with those distinguished as "Metamorphic." The general lithological resemblance of the Sub-Metamorphic rocks of this area to the Dharwar system of South India has been pointed out by the late Dr. W. King[2]; and, judging by Mr. Hallowes' descriptions, those lying to the south of the copper-bearing zone, and described as Metamorphic by Ball, are similar types

[1] V. Ball. *Rec. Geol. Surv. Ind.*, III, 94-103.
[2] Gold Copper and Lead in Chota Nagpore, 1891, pp. 3 and 70.

largely impregnated by granitic intrusions presumably related to the porphyritic granites exposed in Akarsuni hill near Kharsawan.

United Provinces.

50. During the course of his deputation in August and September to survey the glaciers of the Garhwal Himálayas, Mr. J. Coggin Brown recorded notes of some of the copper-ore occurrences which were formerly worked by the natives in this district and in Almora, including those near Askot (29° 46′; 80° 23′), Berinag (29° 47′; 80° 7′), and the Girthi Valley (30° 40′; 80° 8′). As the areas are covered by concessions under prospecting licenses, details of the observations made are regarded as confidential. The ores occur apparently in impregnated bands in the schists of the zone of old rocks occupying a corresponding position in the Kulu region on the north-west, and in the Nepal and Darjeeling regions to the south-east. Lithologically this belt of schists also resembles the Dharwars of Peninsular India.

Engineering Questions.

Malakand tunnel.

51. In July 1905, the Chief Engineer of the Punjab Government requested the advice of the Department with regard to the proposal for tunnelling the Malakand Range in order to lead the water from the Swat river near Chakdara to the Eusafzai Valley for irrigating a portion of the Peshawar district. Samples of the rock forming the range were reported on favourably by the Director, and on the development of exploratory work, Mr. G. H. Tipper was deputed at the commencement of the field season 1906-07 to report on the rocks *in situ.* Mr. Tipper's observations confirm the previous conclusion with regard to the durability of the rocks penetrated by the tunnel. The outer portion of the range consists of mica-schists and other schistose rocks, sometimes slightly pyritiferous, into which has been intruded a massive granite that is fairly constant in character and practically unaltered. It is concluded that so long as the water which passes through the tunnels is comparatively free of grit, the rocks will not suffer seriously from erosion, and the tunnels may be constructed without special lining.

52. Mr. Tipper has also reported on the site of a proposed dam across the Gomal river below Kajuri Kach, where the river has cut a deep narrow gorge through limestones. On account of the way in which the limestones have yielded to erosion, Mr. Tipper has recommended that the tunnel, proposed to be made to carry off the excess of silt-laden water from the reservoir to be constructed above, should be carefully lined with harder material. The detailed reports on the observations made with regard to this site, as well as the proposed tunnels through the Malakand Range, have been submitted to the Chief Engineer for Irrigation, North-West Frontier Province.

Gomal river dam.

53. During March the Director visited Darjeeling in order to advise the Government of Bengal with regard to the protective works necessary in the Happy Valley, in continuation of the measures adopted by the Landslip Committee, of which the Director was a member in 1899.

Darjeeling.

Gold.

54. Mr. La Touche has submitted a special report, which will be published in the *Records*, on the gold of the Loi-Twang area, near the boundaries of the Hsipaw, Kehsi Mansam, and Möng Küng states. This occurrence was brought to the notice of the Government of Burma by the Sawbwa of Hsipaw in 1905. The gold seems to be derived from the sandstones of the Loi-Twang series, or from the thin quartz-veins traversing these rocks, but it was not found actually *in situ*. It occurs in a rather coarse form, in flat flakes or spangles up to an eighth of an inch across, and also in small nuggets. The largest piece found during Mr. La Touche's operations was the size of a small pea, weighing about 18 grains. In spite, however, of the coarseness of the gold, the value of the deposits appears to be very low. Excluding the small nugget above mentioned, the value per cubic yard in the richest gravel met with was not much more than two grains. The gold occurs in the older gravels bordering the streams that radiate from the Loi-Twang range and cut through the sandstones, but is not found, except in very minute particles, in those which are excavated in the shales.

Burma.

55. In consequence of frequent applications for licenses to work the alluvial deposits in Upper Burma, Mr. J. M. Maclaren was deputed, during the field season 1905-06, to report on the work in progress on the concessions already granted, and generally on the conditions for alluvial gold-dredging in the rivers of Upper Burma, with a view of framing regulations to govern future concessions. During the season the following were examined in succession:—

(1) The Upper Irrawaddi river from Katha to the confluence of the Mali Kha and the 'Nmai Kha, the former being examined as far as Kwitao and the latter as far as Samradaru ferry.
(2) The Mole Chaung which falls into the Irrawaddi a little above Bhamo.
(3) The part of the Taiping river within British territory.
(4) The Chindwin river to a few miles above Manbin (about 26° 05′; 95° 50′) in the Singkalin Hkámti state.
(5) The Uyu river which joins the Chindwin near Homalin (24° 50′; 94° 55′), as far as the mouth of the Chaungyi Chaung (about 24° 55′; 95° 25′), with the older gravels in the Uyu valley above Maing Kaing.
(6) The Namma river in the Northern Shan States.
(7) A short reach of the Salween river near the mouth of the Namma.
(8) Some smaller streams in the South Hsenwi state.

As Mr. Maclaren's observations refer to ground covered by concessions held by existing companies, his report is regarded as confidential. To govern all new applications for prospecting licenses the Government of India have decided, in accordance with Mr. Maclaren's suggestion, to limit the areas granted by district officers under alluvial prospecting licenses to 1,600 acres, measuring not more than five miles in length, except in cases of narrow belts of river-gravel, on which extraordinary concessions may be granted to a length of ten miles. It is proposed, before the expiry of the newly granted licenses, to revise the existing general rules that govern the granting of prospecting licenses and mining leases in British India, and members of the mining community interested in this question are invited to send to this Department any suggestions which they think should be considered before the revision is undertaken.

Iron-ore.

Mayurbhanj State.

56. The Director visited Mayurbhanj state in February to inspect the iron-ore occurrences on Gurumaishini hill in company with the expert representatives of Messrs. Tata and Sons, who intend to use this ore in the works which they propose to erect near Sini on the Bengal-Nagpur Railway. The lower slopes of Gurumaishini were found to be covered with loose blocks of hematite, while the massive ore projected through the loose material on all the ridges. The ore *in situ* was solid, massive hematite, which on analysis was found to carry in all cases over 60 and often over 67 per cent. of iron, with phosphorus low enough to make the ore suitable for the manufacture of acid steel. The ore-bodies on Gurumaishini hill resemble those examined previously in the Raipur district, and differ essentially from the occurrences which have been described in other parts of India. With the exception of the clay-ironstones of Lower Gondwana age, which are being worked by the Bengal Iron and Steel Company near Barakar, the principal iron-ores of India are those occurring as thinly-banded schists in the Dharwar system, the granules of ore, either hematite or magnetite, or both intergrown, being mixed with other minerals, quartz predominating. The friable fragments of such ore are suitable for use in the small native direct-process furnaces, and have been used in the past for the manufacture of the iron and steel for which India was at one time famous. But for obvious reasons, ores of this kind could not be used in the modern blast-furnace, without incurring the cost of concentration and briquetting. The ordinary quartz-iron-ore schists exist also in the Raipur district and in Gurumaishini hill; but in both localities the schists appear to have been altered locally by intrusive igneous rocks, with the segregation of large bodies of almost pure hematite. The precise relations of the ore-bodies to the neighbouring schists cannot be stated with any approach to certainty until the country has been opened up; but the most important fact for the present for those whose impressions of India have been formed from the Dharwar schists is the established occurrence of solid bodies of hematite in the country.

Manganese-ore.

Origin of the ores.

57. During 1906 Mr. L. L. Fermor was able to make a detailed examination of the rocks and ores collected from the manganese-ore deposits of Vizagapatam,

Nágpur, Bhandára, Bálághát, and Jhábua. The results of this work have been two-fold. On the one hand they have served to confirm Mr. Fermor's theory quoted in the General Report for 1905,[1] that the Vizagapatam manganese-ore deposits have been produced by the chemical alteration of igneous rocks characterised by the presence of manganese-garnet, potash-felspar, quartz, apatite, and manganese-pyroxene.[2] On the other hand, it is found necessary to revise his conclusions as to the origin of the manganese-ores in the Central Provinces, where the rocks very rarely contain felspar, whilst apatite is very much less abundant than in the Vizagapatam rocks. The manganese-garnets of the two areas have, moreover, been found, so far as can be judged from a single analysis of each, to differ considerably in composition. That of Vizagapatam contains, besides manganese, considerable quantities of iron and calcium, being intermediate in composition between spessartite and andradite. That of the Central Provinces contains only comparatively small quantities of iron and calcium, and approaches much closer in composition to the theoretical spessartite.

The Bálághát and Ukua deposits form the key to the petrogeny of the Central Provinces manganese-ore deposits; by a careful comparison of the rocks collected from these two deposits with one another and with the remainder of those of the Nágpur-Bálághát area, Mr. Fermor has come to the conclusion that the ores in this area originated as sediments, which belong to the Dharwar system, having been metamorphosed in some places sufficiently for the formation of rhodonite in the more siliceous parts of the sediments, and of manganese-alumina garnets in conjunction with the clays. Silicates so formed have since been altered into the oxide ores now being mined, various stages having been found in the passage from spessartite-rock, while other manganiferous sediments have possibly been hardly changed chemically and still exist as oxides merely altered in crystalline structure. In the Central Provinces some of the manganese deposits are included in the series formerly mapped as the Chilpi Ghat series, while those of the Jhábua state in Central India are an extension of the so-called Aravalli series. Both these series lithologically resemble the Dharwars of South India and may be regarded as local

[1] *Rec. Geol. Surv. Ind.*, XXXIII, p. 96.

[2] Concerning the nomenclature of this series of rocks, see p. 22.

developments of the same system, which has in some places been so altered as to be indistinguishable from the presumably more ancient basement crystalline complex in Peninsular India. Thus manganese-ores in the less altered Chilpi Ghat series, where the manganese-silicates are rare, may be of the same age as those associated with the manganese-silicates in the crystalline complex.

Inspection of manganese-mines.

58. At the request of the Central Provinces Administration, Mr. L. L. Fermor inspected, with the courteous assistance of the Managers, certain manganese-ore quarries during December in the districts of Nágpur and Bálághát, Central Provinces. His report, which shows that on the whole the ore-deposits are being thoroughly worked, has been forwarded to the Honourable the Chief Commissioner, and extracts will be supplied to the mine-owners for their information.

Petroleum.

Burma.

59. Owing to the rapid development of the petroleum industry in Burma, numerous difficult questions have arisen in connection with the disposal of concessions to European companies, whose work along modern lines, and with large capital, has naturally affected the economic conditions of the hereditary oil-diggers or *twinsas*. In order to assist Government in dealing with these questions, a systematic survey of the areas and of the industry generally was commenced last year, the work being entrusted to Mr. E. H. Pascoe, who has shown an ability and tact in dealing with these complicated problems difficult to over-praise. Most of Mr. Pascoe's reports have been treated, in the interests of the companies concerned, as confidential; but certain of his general conclusions, and his geological observations, will be of general interest.

Yenangyaung field.

60. Careful comparison of the numerous boring records and the geological characters of the Yenangyaung field show that the oil-bearing sands, instead of being continuous over the whole dome, are very limited sand-banks in which the oil is stored. The great variation in thickness, horizontal extent, and level of each of them points to this, as also does the pronounced and abundant "current-bedding" so typical of the strata immediately above. Perhaps one of the most interesting and puzzling features of this area is the occurrence of the largest quantities

of gas, *not* in the centre, where the anticlinal crest reaches a maximum elevation, but at a considerable distance further south: in fact the field appears to terminate southwards as a gas field.

With regard to the drilled borings, several deeper oil-sands have been discovered by the Burma Oil Company, since Dr. Noetling published his Memoir,[1] and these have generally proved to be much richer than those above. About 175 holes have been sunk in various parts of this field.

The Twinzas.

61. With regard to the shallow hand-dug twinza wells, the last remaining sites available within the reserved areas of Twingon and Bèmè await allotment, after which the native oil industry must soon begin to wane unless the Burmans succeed in finding some means of reaching a depth greater than 400 feet, which at present is their limit. Their hereditary rights to win and dispose of all the oil they are capable of reaching have been fully and generously recognised by Government, and the time is now evidently not far off when the crude, wasteful method of digging by hand and working with somewhat indifferent success the shallow sands must be entirely superseded by the steam-driven drill, by which a sand, whether 300 or 3,000 feet deep, can be pumped with equal success.

62. One of the questions under consideration was the minimum distance allowable between the twinzas' wells, and on this question Mr. Pascoe has submitted a detailed report. From his statistics with regard to the rate of decline of Burmese wells and the mutual interference in yield, it is evident that the drainage area of a well tapping shallow sands—especially those between 300 and 400 feet below the surface—extends beyond a radius of 60 feet, which is the minimum distance allowed between any two wells. In a field like that of Yenangyaung, where the sands are so variable, inconstant, and unequal in porosity, this is necessarily only an approximate statement; but the average well would certainly suffer—in some cases fatally—should the distance limit of 60 feet be diminished. Before the twinzas learnt the use of the diving dress and air pump, they could not enter the oil sands to any great depths, but with this curious addition to their ancient methods they are now able to deepen their wells, and so to extend their horizontal sphere of influence.

[1] *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 2.

63. During the first month of 1906 the new miocene anticline discovered by Mr. Macrorie, Geologist to the Burma Oil Company, was examined. This extends north-north-west to south-south-east in the neighbourhood of Seiktein, Myingyan district, and is succeeded eastwards by three other anticlines all trending in the same direction. The most westerly, which passes through the village of Kabat, was practically the only one inspected. The arch is an asymmetrical one and shows no evidence of fracture; structurally the country looks promising from an oil prospector's point of view. There are two facts, however, which damp one's hopes: these are, firstly, the distance of the locality from what has so far appeared to be the boundary of the oil-belt in Burma, and, secondly, the proximity of an extinct volcano. This area has been more fully described in a paper by Mr. Pascoe published in *Records*, Vol. XXXIV, part 4.

Seiktein field.

64. The next area examined was the northern part of the Gwegyo anticline, Myingyan district, around the village of Ayadaw. From a geological point of view this region is of great interest, and the numerous excellent sections in stream-courses beautifully illustrate the effects of large faults upon structure and topography. The presence of so much faulting close to the anticlinal crest renders the prospects of successful boring very doubtful. A paper on this area is also published in *Records*, Vol. XXXIV, part 4.

Gwegyo.

65. The blocks in the Singu field were visited chiefly with a view of locating the southern boundary of the actual oil-bearing territory. This could not be done with any exactitude, as the field has been little developed hitherto; but in all probability the line should be drawn somewhere within Block 56N. The oil-sand in this field, unlike those in either Yenangyaung or Yenangyat, is very constant in depth and thickness, and the yield of a well can be reckoned with more certainty and accuracy. The discovery in one well of a second oil-sand below the one hitherto exclusively worked is a point of much interest and importance.

Singu.

66. The Yenangyat field, although a continuation of the Singu anticline across the Irrawaddi, is not as promising as it was at first thought to be. Altogether some 260 holes have been drilled here by the Burma Oil Company, Minbu

Yenangyat.

Oil Company, and Rangoon Oil Company, but the percentage of abandoned bores is as high as 24, that at Yenangyaung being about 15. The country is very hilly, and it is often necessary to construct an elaborate road and to bridge small ravines before an engine and derrick can be erected upon the selected site. Owing to the asymmetry of the flexure, the oil-pools do not lie vertically beneath one another, but recede westwards in the deeper sands. The most suitable distance west of the exposed anticlinal crest for a well-site becomes therefore a matter for very careful calculation, and is influenced by the degree of asymmetry of the anticline, by the depth of the oil-sand sought after in this particular spot, and by any minor folding or local disturbance of the strata. Frequently a suitable site when selected has to be abandoned on account of topographical difficulties which interfere with the work of exploitation. Although many large wells have been struck in this field, the yield is liable to decline rapidly, and the capabilities of the field generally are far below those of Yenangyaung, in spite of its much greater size. The extreme north of the field has not yet been conclusively tested, but indications are sufficiently favourable to warrant a thorough exploration with the drill: the southern portion below Block 13 may be looked upon as "dry."

Salt.

Northern Shan States.

67. Towards the end of December 1905 Mr. T. D. La Touche examined the brine well at Bawgyo (22° 35'; 97° 16' 15") in the Hsipaw state, Northern Shan States. The well now in operation measures 4 feet square by 45 feet in depth, and is situated at the foot of a precipitous scarp of limestone marking the line of a fault, but no explanation has been offered as to the origin of the brine. The strength of the brine varies with the season, due probably to the varying inflow of surface fresh water, for samples taken on the 8th of June 1890 by Dr. Noetling contained 12·53 per cent. of dissolved salts, while the samples collected by Mr. La Touche on the 19th of December 1905 contained 25·58 per cent. of dissolved salts. The two principal salts in solution are sodium chloride, forming about 60 per cent., and sodium sulphate, forming 35 per cent., of the total dissolved salts. The salt is prepared for the market by concentration of the brine in shallow boilers artificially heated, and the output of imperfectly purified sodium

chloride obtained in this manner amounts to about 164 tons per annum, to which should be added about 40 tons of the scale composed largely of sodium sulphate. It is reported that a second well was formerly worked in this locality, but no trace of it now remains, and it appears to have been neglected because of the red colour of the salt produced from it.

Silver, Lead, and Zinc.

Northern Shan States.

68. During May 1906 Mr. Maclaren examined the old silver-lead-zinc mines in the neighbourhood of Baudwingyi (97° 22′; 23° 9′) in the Tawngpeng state, 36 miles north of Hsipaw, Northern Shan States, where a concession, taken by the Great Eastern Mining Company in 1900, is now in the possession of the newly constituted Burma Mines, Railway and Smelting Company. As Baudwin comes within the area being surveyed in detail during the current field season by Messrs. T. D. La Touche and J. Coggin Brown, it is proposed, before the issue of the next Annual Report, to publish a special paper in the *Records*, combining the information collected with regard to this interesting area. Mr. La Touche has already reported the existence of a great overthrust fault, which has been traced from south to north from Panghsapyé (22° 42′ 30″; 97° 17′) to the Baudwin area, a distance of about 30 miles. Along this overthrust the Naungkangyi beds have been pushed up westwards over the Namhsim sandstones, so that a broad belt of the former intervenes between the two areas occupied by the sandstones, giving the appearance at the surface of the western band of younger Namhsim sandstones dipping under the older Naungkangyi beds. Another thrust nearly parallel to the first, insufficient to bring the Naungkangyi beds to the surface, passes through Baudwin and forms the mineralised zone. Mr. Maclaren has furnished interesting notes on the work done by the Chinese, who deserted the place about fifty years ago, while Mr. Brown has made a special study of the ores and slags.

GEOLOGICAL SURVEYS.

Andamans and Nicobars.

Andamans.

69. During the season 1904-05, Mr. G. H. Tipper was deputed to accompany an exploring party among the Andaman and Nicobar Islands, but owing to various interruptions during the recess season of 1905, and subsequent deputation to Balúchistán in September, the results of his observations could not be worked out until the recess season of 1906. The work carried out in the Andamans has resulted in a very great advance on our previous information as to the geology of the Islands, which was summarised in a paper by Mr. R. D. Oldham in 1885.[1] Mr. Oldham distinguished two sedimentary groups in the Andamans:—

The Archipelago series—Miocene? developed in Ritchie's Archipelago, part of the North Andaman, Interview Island, etc.

The Port Blair series—Eocene? developed in and around Port Blair, South Andaman.

He suspected the presence of a possibly older series in the jaspers and quartzites of the South Andaman.

70. Mr. Tipper having discovered fossils in several of the rocks previously thought to be unfossiliferous, is now able to mark a number of definite horizons, and to distribute the associated strata with fair precision. His results are summarised in the accompanying tabular statement.

[1] *Rec. Geol. Surv., Ind.*, XVIII, 135-145.

Geological age.	Sub-division.	Description of strata.	Distribution.	Fossils.	Correspondence with Oldham's divisions.
RECENT AND SUB-RECENT.	...	Raised beaches, beach formations, mangroves.	...	...	
MIOCENE ?	...	Chiefly clays with some coral sands.	Ritchie's Archipelago, East coast.	Radiolaria and sponge spicules.	Archipelago group in part.
MIOCENE	Burdigalian	Foraminiferal limestone	Interview Island	N. Niasi, Amphistegina Niasi, Lepidocyclina sumatrensis.	Ditto.
		" sands	Paget Island, White-cliff Island.		
		Shell marls	West coast.		
EOCENE	Lower Lutetian or Upper Ypresian (Laki group).	Coarse sandstones and conglomerates.	North Andaman, Middle Andaman in part.	*N. atacica*, *A. granulosa*.	Ditto.
		Micaceous sandstones and shales.	South Andaman	Leaf impressions, Tooth of *Diodon*.	Port Blair series in part.
CRETACEOUS	Upper	Serpentines, gabbros, and diorites.	Saddle Hill and peak, Port Mouatt, Corbyn's cove, Cinque Islands, etc.	...	Serpentine series.
PRETERTIARY SEDIMENTS.	Lower ? Cretaceous.	Pink and white porcellanic limestones.	South Corbyn's cove, isolated exposures in North Andaman.	...	A possibly older series.
		Jaspers and quartzites	Isolated outcrops in all the main islands.	...	

71. Of the formations tabulated above, the eocene rocks cover the largest extent of country. In the North Andaman they are chiefly coarse calcareous conglomerates and sandstones. The latter have yielded fossils, *Nummulites atacica* Leym., *Assilina granulosa* d'Arch., *Nautilus* sp., and *Turritella* sp. The occurrence of the two first together is sufficient to mark these beds as equivalent to the Laki group (see p. 17). The sandstones and shales of the South Andaman have so far yielded no nummulites. The only fossils known are some poor leaf impressions and a tooth of *Diodon*, identified as such by Lydekker (*Rec. Geol. Surv. Ind.*, Vol. XIII, 59, 1880). Traced northward these sandstones become more and more conglomeratic and like those of the North Andaman, and although the Middle Andaman is almost unknown geologically there is very little doubt that there is only one formation and not two. The miocene (Burdigalian) rocks on Paget Island are seen resting unconformably on the eocene conglomerates. They consist of shell marls with foraminifera below and soft foraminiferal sands above. The same foraminifera are found in the two deposits. They have been identified by Mr. Vredenburg as *Nummulites Niasi* Verbeek, *Amphistegina Niasi* (=*N. Niasi* II Verbeek), and *Pulvinulina* sp. Of the other fossils in the shell marls are *Pecten* (*Amusium*) *placunoides* Martin, *Amusium* sp., *Chlamys* sp., *Tellina* sp., *Dione* sp., etc. The marl is so crowded with lamellibranchs that it is almost impossible to develop any fossils sufficiently for determination. On Interview Island the rock is a rather hard foraminiferal limestone with *N. Niasi* and *Lepidocyclina sumatrensis*. There are also numerous *Globigerinæ*. There is no doubt that these all belong to one deposit. Beds with *N. Niasi* have been classed as Burdigalian by H. Douvillé.

The rocks of the Archipelago referred to the miocene are generally non-calcareous clays, and contain radiolarian remains and sponge-spicules in small quantities. They have been referred to the miocene from their position, from their fossils, and from their generally undisturbed appearance.

72. The serpentine series is widely distributed over the main islands. The prevalent rock is a dark-green serpentine with thin veins of chrysotile. Occasionally fairly fresh gabbros and weathered diorites are met with. This series possibly corresponds with the basic intrusions of Upper Cretaceous age so widely distributed in extra-peninsular areas.

73. The pre-Tertiary sediments are so classed because there is no absolute proof of their age, except that they must be older than eocene, as pebbles of these rocks are found in the eocene conglomerates of the North Andaman. This argument may be pressed a little further, as jasper and quartzite pebbles are found in conglomerates along with what appear to be pieces of decomposed serpentines. They are perhaps pre-Upper Cretaceous or Upper Cretaceous. Lithologically the pink and white porcellanic limestones are exactly similar to the Neocomian limestones of Balúchistán, and like the latter occasionally occur in association with the serpentines. The jaspers and quartzites occur as small scattered inliers in the eocene sediments.

The recent and sub-recent deposits chiefly developed on or near the coast present no very interesting features.

Comparison with the rocks of the Arakan Yoma shows that the Andamans are a continuation of the same system. Not only are the jaspers, quartzites, and serpentines developed in the same way, but, as shown by the collections made by Mr. Datta in 1892, the main mass of the Arakan Yoma is composed of sandstones, shales, and conglomerates lithologically similar to those of the main Andaman Islands. The same fossils, ***Nummulites atacica*** and ***Assilina granulosa***, occur in a coarse sandstone, similar in every respect to that of the North Andaman Islands. Beds with *Nummulites Niasi* are also developed on the west coast of the Yoma and are there associated with typical Gáj fossils, *Echinolampas Jacquemonti*, *Meoma* sp., *Pecten* sp.

74. The structure of the Andamans is that of a disturbed anticline, thrust or folded over to the west. The miocene beds which rest unconformably on the eocene rocks are only slightly disturbed, so that the main portion of the movement must have ceased before their deposition. Connected with the structure is one very interesting feature. Both the sub-aërial and sub-marine slopes are much steeper to the east than to the west. A section across the Andamans shows a long gradual slope from west to east culminating at some point near the east coast, a steep eastward slope continued under the sea until about midway between the Andamans and Barren Island. Such a steep easterly slope seems to be contrary to what would naturally be expected from a fold thrust over to the west. The steeper slope ought normally to be to the west. It is probable, therefore, that to the eastward there is a fault, and that in the neighbourhood of the fault the volcanoes, Barren Island and Narcondam were formed.

75. On the Nicobar Islands only very limited opportunities occurred for geological work before the party was compelled to return to the Andamans. The following are, stated briefly, Mr. Tipper's conclusions with regard to the Nicobar rocks. There are apparently two sedimentary series developed in the islands:—

Nicobars.

1. A clay formation developed on Nancowry, Kamorta, Car Nicobar, etc.
2. A sandstone and shale formation on the Great Nicobar, Little Nicobar, and Katchal.

The clay formation is chiefly of magnesian clays with subsidiary conglomerate bands of igneous rock pebbles. Radiolaria and sponge spicules are found in the clays, and foraminifera, corals and lamellibranchs in the less coarse conglomerates. These clays are very little disturbed, and are correlated provisionally with the supposed miocene clays of the Andamans.

The sandstones and shales are much disturbed and form fairly high hills. On Katchal are some small inliers of quartzite and also some conglomerates like those of the Andamans. These possibly correspond with the eocene.

Baluchistan.

76. Mr. E. Vredenburg, assisted by Mr. G. H. Tipper, spent the field season of 1905-06 in Balúchistán, and completed the preliminary survey of that region. The work included the provinces of Sarawán, Jhalawán, and Mekran in the State of Kelát, the State of Las Bela, and the southern portion of the State of Kharán.

77. The greater part of Sarawán and Jhalawán and the eastern portion of Las Bela consist of a vast series of folded strata extending in age from liassic to pliocene. The middle stages of the Jurassic are represented by a massive limestone of enormous thickness, the lias by an equal thickness of darker and thinner-bedded limestones. At one locality to the north of Kelát, Mr. Tipper discovered beds of Permo-Carboniferous or Carboniferous age. The Lower Cretaceous is represented by the "belemnite shales" and white limestones, with which we have already been made familiar by Oldham's and Griesbach's explorations in the Harnai and Thal Chotiali region. The Upper Cretaceous includes a variety of shales, limestones, and sandstones, associated with volcanic material,

Stratigraphy.

and great basic intrusions of basalt, dolerite, and serpentine, associated with magnesite. There are two principal divisions of the eocene, the Laki series, with a few coal seams, only observed in Northern Sarawán, and the overlying Khirthar series which is the main horizon of the nummulitic limestone. The overlying Nari consists principally of limestones and sandstones, with nummulites and lepidocyclines indicating its oligocene age. The upper miocene and pliocene are represented as usual by the Siwalik formation. All these divisions correspond with those that had already been recognised in other parts of Balúchistán.

78. The western border of Sarawán and Jhalawán and Las Bela, with practically the whole of the Mekran province, is occupied by the formation of flysch facies known as the Kojak shales. The age of this formation, which hitherto had remained undecided, has now been settled by the discovery of several fossiliferous zones, with fossils ranging from the horizon of the Lower Nari to that of the Gáj. The Kojak shales correspond, therefore, with the oligocene flysch of Europe, as has already been stated by Mr. Vredenburg in previous numbers of the ***Records*** (Vol. XXXIV, pp. 90 and 182). In the southern part of the Mekran province, the Gáj horizon (uppermost oligocene) passes conformably upwards into a great thickness of sandstones of lower to middle miocene age named after the Hingláj mountains which they constitute.

79. One of the most important results of the survey has been the recognition of a number of stratigraphical breaks in the Cretaceous and Eocene, which, although not emphasized by any discordance of stratification, nevertheless correspond with prolonged interruptions of sedimentation. This observation has dispelled the notions previously entertained as to a gradual passage from Cretaceous to Tertiary (*loc. cit.*, p. 182).

Economic Geology.

80. The various districts referred to in the above notes include most of the less arid portions of Balúchistán. This is especially the case with the Mekran province, whose prosperity could be greatly enhanced by extending the present system of irrigation. The ancient artificial dams and terraced fields known as "gorband" are extremely numerous throughout Jhalawán, Sarawán, and the Mekran. In a great many cases these structures have been erected as dams across considerable streams, but have now fallen into disrepair, and have been largely

carried away by floods. The perennial rivers of the Mekran, such as the Hingol, the Mashkhel, the Dasht, and some of their tributaries, could be turned to account for irrigation to a much greater extent than they are at present by constructing dams at suitable places.

81. With regard to the chances of artesian wells, it is to be noticed that the talus formation that yields the artesian water of Northern Balúchistán is not greatly developed in the region here referred to. Owing to less arid conditions, combined frequently with a smaller relative altitude of the hills, this formation does not attain anything like the proportions which it has round Quetta. It usually spreads out at a very shallow angle, so that a high pressure in the underground reservoir cannot be expected.

82. The *sulphur* mines of Sanni were visited by Mr. Tipper. The sulphur occurs in the Siwalik sandstones and clays. The mines have not been worked for many years and have collapsed to such an extent that they have become very difficult of access, besides which, parts of them have caught fire. Some of the clay bands are so full of sulphur that they burn with ease. The amount of sulphur impregnating the rock seems quite sufficient to hold out prospects of remunerative working, especially taking into account the favourable situation of the mines at the edge of the Kachhi plain. In the neighbourhood of the sulphur mines the rock is traversed by numerous veins of *alunite*.

83. The ancient *lead* mines of Shekran, fourteen miles north-west of Khozdar, in Jhalawán, which were also visited by Mr. Tipper, have been abandoned for a much longer period than those of Sanni, and are still more obstructed with fallen débris, so that it is no longer possible to examine them as was done by Masson in 1843, and by Cook in 1859 (*Transactions of the Med. and Phys. Soc. Bombay,* No. VI, pp. 1-103, 1861), without first clearing out the old workings. The mines are situated in the limestones of the Lias and Middle Jurassic, which, in the neighbourhood, are profusely injected with intrusive delerite and serpentine. The only fragments of ore that Mr. Tipper was able to obtain consist of cerussite. The ore was formerly smelted in the neighbourhood of the mines. The presence of *antimony* in all the slags indicates the existence of ores of this metal, but the mineral containing it could not be traced. The slags do not contain any silver. The disappearance of timber is probably largely responsible for the abandonment of these mines, which are not favourably situated as regards fuel, for the coal-bearing formation (Laki series) is entirely

absent from Jhalawán. In Northern Sarawán, *coal* of inferior quality was observed, and some small deposits of red oxide of *copper*, which appear to be of little value.

84. *Barytes* was discovered by Mr. Tipper, scattered through the belemnite shales at their junction with the underlying Jurassic limestones. The mineral is fairly abundant at Pabni, a locality situated about two days' march from Karachi.

Burma.

85. Mr. T. D. La Touche was employed throughout the field season of 1905-06 in the Northern Shan States, and in addition to an extension of the map over previously unsurveyed ground he made a special examination of a reported occurrence of alluvial gold in the northern part of the Southern Shan States. The results of this work are mentioned on another page (p. 36).

86. Before taking up new ground in the eastern part of the Shan plateau, Mr. La Touche made a special examination of the limestone ridge near Tonbo to the east of Mandalay. These limestones were regarded as Lower Palæozoic in age by Dr. F. Noetling, being grouped by him with the crystalline limestones of Mandalay hill.[1] Subsequently Mr. P. N. Datta found fragmentary fossils in these rocks, which, in Dr. Noetling's opinion, indicated a Silurian age.[2] This conclusion remained unchecked until Mr. La Touche visited the ground last year, and, by the discovery of numerous and well-preserved specimens of *Fusulina* and corals, he showed the presence of Permo-Carboniferous beds, the occurrence of which in various parts of the Shan plateau has been already announced.[3]

87. Mr. La Touche's subsequent work in the eastern part of the plateau revealed further occurrences of these rocks, one of them, near Kehsi Mansam, being found to contain well-preserved specimens of *Productus* and other brachiopods, beside *Fenestella*, corals, and *Fusulina*. Practically all the series found in the western part of the plateau have now been found repeated to the south and south-east of Lashio, and considerable additions have been made to the collections of fossils, especially those of Lower Palæozoic age.

[1] F. Noetling. *Rec. Geol. Surv. Ind.*, Vol. XXIV, p. 104.
[2] General Report, Geol. Surv. Ind., for 1899-1900, p. 99.
[3] *Rec. Geol. Surv. Ind.*, XXXIII, 103.

88. An interesting occurrence of olivine-basalt near the village of Nawng-tao (22° 30′; 98° 1′), on the road between Lashio and Mong Yai, has been described in a paper which will be published in *Records*, Vol. XXXV. The basalt occurs as a dome-shaped mass, probably the remains of an old volcanic neck, rising through the Tertiary clays and sands, with dykes radiating from it on all sides, and showing a regular columnar structure.

89. The results of Mr. Pascoe's survey of the oil-fields are reviewed on another page (*supra*, p. 40).

Central India.

Area surveyed.

90. The Central India party, consisting of Messrs. C. S. Middlemiss, H. Walker, G. deP. Cotter, and Sethu Rama Rau, continued the work begun last season, with the result that the geological mapping of the following standard sheets on the 1″ = 1 mile scale has been completed:—395, 329, 330, 331, 332, 333, 353, 354, 394, 395, and 410. In addition, portions of the following have been mapped:—301, 302, 306, 328, 334, 352, 393, 408, and 409. This brings the total area now completely surveyed in detail on the 1″ scale to over 10,800 square miles since and including Mr. Vredenburg's work in Bhopal.

Geology.

91. The new portion mapped and described this season consists very largely of Deccan Trap, with a few outcrops of older formations lying marginally or as inliers with regard to the trap; besides laterite, alluvium, and soils.

Archæans.

92. Archæans of the Narbada valley were just touched by Mr. Cotter's operations in Nemawar near Kanod Sukras, and Kissenpur, where they consist of imperfect exposures of (1) quartz-felspar gneiss with biotite and sphene, (2) biotite-granite, and (3) quartz-schists and quartz fault-rock.

Bijawars.

93. In the same area rocks belonging to the Bijawar series are represented by some very small inliers among the Trap in the south-east corner of sheet 333. They consist of rather conglomeratic, and also slightly schistose, massive, white quartzites. Rocks of the same series, at the eastern end of this season's surveyed area, were also met with by Mr. Walker, forming isolated hilly ground south of Omarpani.[1] They

[1] Wrongly marked on the map with *Mem. Geol. Surv. Ind.*, Vol. VII, part 1, as Rewa sandstone, owing to a confusion of the places Omarpani and Omaha.

consist of quartzites, and fine-grained crystalline limestone with bands of hematite ore.

Vindhyans.

94. Mr. Walker found the Vindhyans in his part of the country to be almost confined to a long narrow ridge of strata slightly tilted to the north, about 22 miles long, and nowhere more than 2 miles wide, lying nearly east-west across the middle of sheet 410 and continuing westward into direct connection with the Vindhyans mapped by Mr. Vredenburg in sheet 394. They include representatives of Lower Vindhyan (?) shales—in traces only—Kaimur conglomerate and sandstone, the sandstones of the Rewa group and the Bhander group, with only a very poor development of the intervening shaly layers. These continuous outcrops of the regular Upper Vindhyan sequence are surrounded on all sides except the west by Deccan Trap, and they consequently come to an abrupt end eastwards near Deori (sheet 410). The only other exposures of Upper Vindhyans in this locality consist of small isolated hillocks, generally lying to the south of the main scarp, but especially interesting because of the high angle of dip shown by the beds, which varies from 20° to as much as 60°—a feature unknown in the ordinary plateau areas of the Vindhyans, where they are characterised by low dips of 10° and less. The tracing of these broken exposures eastwards so as definitely to correlate them with the Upper Vindhyans of the Kaimur Range was carried out by Mr. Walker, who has shown it to be highly probable that the provisional classification of the Upper Vindhyans, adopted by Mr. Vredenburg in Bhopal and followed by the present Central India party, is in agreement as regards its main subdivisions with that formulated by F. R. Mallet in the eastern parts of the Upper Vindhyan area.

95. In the areas lying north-west of Bhopal state, surveyed by Mr. Middlemiss and Sub-Assistant Sethu Rama Rau, the Vindhyans were found to be represented by a number of isolated inliers of the upper (probably uppermost) groups of the system, completely surrounded by Deccan Trap. As surveyed during last season, they extend in patches northwards from the neighbourhood of Narsingarh (north-west corner of sheet 354), across the western half of 353, becoming of less importance further north. They are inclined at very low angles, averaging only a few degrees to east-north-east and north. On account of the complete isolation of some of the smaller of these in sheet 353, it is impossible to determine their exact horizon

among the Upper Vindhyans, except that they probably represent one or other of the uppermost groups. On the other hand, sheets 328, 329, 330, and 331 were found to be entirely wanting in any inliers of Vindhyans, whilst the country further west shows no promise of any more inliers in that direction. This fact taken in connection with the already determined absence of such inliers west of, and including, the western portions of sheets 355, 356, 357, and 358 point to a probable limit of the Vindhyans in this direction, due either to pre-Trappean denudation, or to lines of faulting with down-throw to the west. The change in either case is a very striking one.

Lameta series.

96. A small extent of the Infra-Trappean Lameta series, near Tendukhera, Central Provinces (sheet 410), has been mapped by Mr. Walker. The series is everywhere horizontal, and spreads out as wide platforms underneath the Deccan Trap, which forms caps and summits to isolated hills and low spurs. The normal nature of the sequence, and the near connection in time between the Lametas and Deccan Trap, are thus strongly suggested. The base of the series is never clearly seen, but the total thickness must exceed 100 feet. Mr. Walker describes the rock as generally calcareous and of pale colours, containing much sandy admixture and occasionally cherty. The uppermost layer is characterised by containing well-rounded pebbles of quartz, quartzite, and bright red jasper. A light-reddish coloured sandstone was found at one place.

97. Somewhat similar Infra-Trappean deposits were also touched by Sethu Rama Rau in the Lohar R. (sheet 306), and by Mr. Cotter near Kátkut (sheet 334). These, in conformity with Mr. Vredenburg's [1] work further west, are accepted as being of Lameta (= Bagh) age, rather than as Gondwanas as mapped by Mr. Bose.[2]

Deccan Trap and Intertrappeans.

98. The descriptions of the Deccan Trap contained in the various reports of the Central India party agree with each other very closely, and also with what has already been said in the Annual Report for last year.[3] No fresh light has been shed on the question of the separation of the mass into distinct petrographical horizons, nor on that of

[1] General Report, Geol. Surv. Ind., for 1902-03, p. 20.
[2] *Mem. Geol. Surv. Ind.*, Vol. XXI, part 1.
[3] *Rec. Geol. Surv. Ind.*, Vol. XXXIII, part 2, 1906, pp. 107-108.

the exact manner of its extrusion and solidification. A few additional items of information gathered refer to some intercalated beds of red clay, and to some well-developed calcareous and siliceous Intertrappeans with fossils. Mr. Cotter describes a number of localities at which red clay is found among the Deccan Trap. Some of his sections of the southern scarp of the Trap plateau show at least two bands at different horizons. He remarks, with regard to these, that they are rarely more than a foot thick, that they are invariably horizontal and with sharply defined boundaries. Similar clay bands were met with by Mr. Middlemiss at two places in sheet 331. There seems no reason for doubting the ordinarily accepted view that they are old Intertrappean soils.

99. The Intertrappean fresh-water deposits which have been mapped and described this season are much more noticeable on account of their importance and the range of country over which they extend. Messrs. Middlemiss, Walker, and Sethu Rama Rau all found, in their respective areas, long, broken outcrops of these strata contouring the hills in the way characteristic of a thin horizontal stratum, although the outcrops are never actually continuous beyond a mile or two. In many places the Intertrappean band, which is seldom more than 10 feet thick and generally much less, becomes lost as a continuous exposure, but persists in skeleton form as scattered blocks of limestone, partly silicified limestone, or chert, lying as groups and masses, or distributed in small pieces as if scattered broadcast over a number of limited areas. These "residual blocks" seem to owe their present detached arrangement chiefly to surface weathering and differential denudation of the bed itself and of the over and underlying beds of basalt. At one locality near Kankria (sheet 329) where the Intertrappean bed is particularly well and continuously developed, Mr. Middlemiss found it to consist of 6—10 feet of cream-coloured marl and limestone, the upper layers of which were crowded with singularly well-preserved specimens of *Physa*, from which a good collection was made.

100. It is of interest to note that the respective areas where red-clay bands and Intertrappean aqueous deposits are found do not comingle, a fact which bears out the interpretation that the former represent old land surfaces and the latter areas which were under water, or at least capable of retaining some water in the shape of abundant isolated little pools. The present altitude above sea-level

of the Intertrappean aqueous deposits varies between 1,360 feet in sheet 328 to 1,954 feet in sheet 409, giving a range of about 600 feet. Variations within this level, considering the horizontal distances implied, may easily be accounted for by a scarcely perceptible bending or faulting acting on a single stratum belonging to one general horizon. We possess no evidence so far in this region for more than one horizon of these Intertrappeans, although the bed is sometimes duplicated (Walker).

Laterite.

101. Lateritic caps on the Deccan Trap plateau were met with this season in the areas surveyed. On account of their relative thinness and horizontality, they have often suffered the same kind of local disintegration as have the Intertrappean exposures, and become again aggregated locally into patches of "residual blocks" of some importance and extent. They naturally shade off into pellety and gravelly laterite spread over the slopes and valleys in the neighbourhood of the original massive, tubular variety. The most numerous and continuous exposures of laterite were found by Sethu Rama Rau in the eastern portions of sheets 352 and 353. Their proximity, where separated, and their gradual coalescence towards the north argues a once continuous sheet, subsequently dissected by denudation. Among the lateritic area near Konkangarh and Isarwas of Sironj pargana (sheet 352), and near Kotra and Agra (sheet 353), Sethu Rama Rau describes many blocks of bauxitic laterite occurring as segregated rounded boulders in the brecciated and pellety variety of laterite, in the former case (a particularly rich one), and as residual blocks or on talus slopes in the latter.

101. The supposed copper locality at Tamba Bouli hill, 1 mile north-north-west of Biana (sheet 329), is only laterite.

Calcareous rock of doubtful age.

102. Near Khampel and Khandel (sheet 306) Sethu Rama Rau describes a superficial calcareous rock containing minute agate and jasper particles. It lies on the Deccan Trap plateau near its southern scarp and is much quarried for building purposes. A similar rock is described by Mr. Middlemiss from between Minagaon and Gugahera (sheet 329). On examination of this in thin section both were found to be made up chiefly of small rounded fragments of a yellow limestone set in a matrix of calcite. They are probably the equivalents of the "sub-recent

calcareous concrete" described by Wynne in Cutch,[1] and the miliolitic limestone from Kathiawar,[2] but no miliolites or other organic substances were detected in them, nor is the rock typically oolitic.

Alluvium and soils.

103. The alluvium keeps mainly to the river valleys and larger streams in the northern plateau area. Besides consisting of the usual buff-coloured clay, sometimes with kankar, many exposures show beneath it a coarse subangular conglomerate with sandy matrix containing recent shells. The conglomerate is sometimes as much as 20 feet thick. In the Narbada valley the alluvium is not confined to the vicinity of the stream-beds as a rule, but lies as a thin covering over the whole face of the country, concealing the older rocks. The soils present no features of novelty.

Central Provinces.

104. After the completion of his work in the Nágpur Museum during November and part of December, Mr. P. N. Datta commenced the survey of the south-east parts of the Bhandára district (Quarter-sheet, 72 S. E.) Among the rock groups mapped are—(1) a series of sandstones and grits with conglomerates, provisionally named, for want of evidence as to age, the Dhas Nadi series, (2) Vindhyans, (3) Dharwars, and (4) Archæan gneisses and schists with various intrusive dykes. No feature of unusual interest has been reported in the area examined.

Kashmir.

The Gondwana question.

105. The state of our evidence with regard to the age of the Lower Gondwana beds was summarised in the General Report for 1902-03.[3] Dr. Noetling had reported the discovery near Khunmu in Kashmir of *Gangamopteris* in beds which he regarded as immediately below Productus limestones and Fenestella shales in a conformable series. In the Report for 1903-04 it was pointed out, as the result of Mr. Oldham's observations,[4] that the *Gangamopteris*-bearing shales were not seen in direct contact with the Productus-limestone series, and that although it was possible, even probable, that they are stratigraphically below the latter, this section alone could not be accepted as positive direct evidence to show that *Ganga-*

[1] *Mem. Geol. Surv. Ind.*, Vol. IX, part. 1.
[2] *Mem. Geol. Surv. Ind.*, Vol. XXI, p. 126, and *Q. J. G. S.*, Vol. LVI, p. 559.
[3] Page 22.
[4] *Rec. Geol. Surv. Ind.*, XXXII, 152.

mopteris existed before the Productus limestone. Mr. H. H. Hayden took the opportunity, while on deputation in Kashmir during October, to make a plane-table survey of the Khunmu exposures, and the

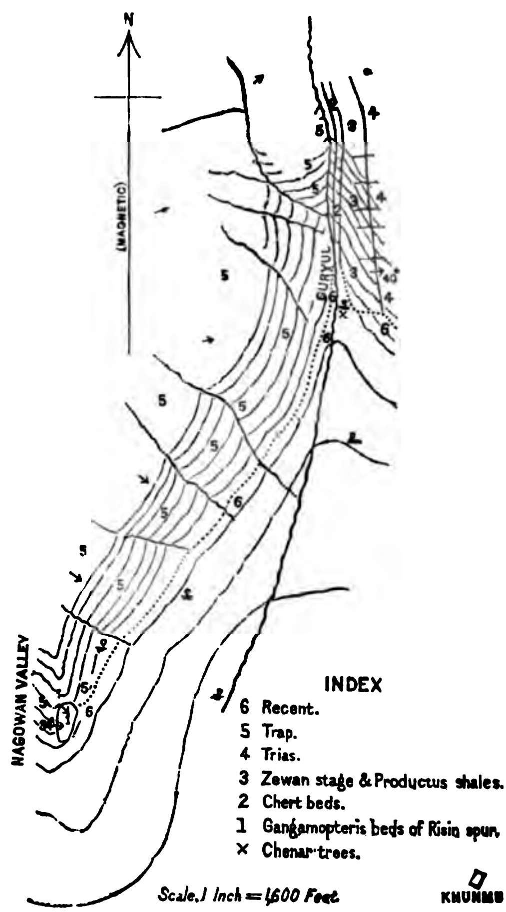

FIG. 1.—Map of the ground north-west of Khunmu.

reproduction of his map on a reduced scale given in fig. 1 shows that the small exposure of plant-bearing shales is not only so far removed from the Productus limestones that the latter could not be legitimately regarded as resting on the former in a conformable sequence, but the two series are dissimilar in direction of dip. In consequence of a similar criticism made by Mr. R. D. Oldham, I was compelled last year to give up what I had previously accepted on Dr. Noetling's testimony to be stratigraphical proof that *Gangamopteris* existed before the Productus limestone was formed, and the Palæozoic age of the Lower Gondwanas thus still rested on indirect evidence only.

Mr. Hayden, however, was not satisfied with mere criticism of the unsatisfactory evidence at Khunmu, but applied himself with characteristic energy to a careful examination of the other exposures of the so-called Zewan beds, and was rewarded by the discovery of *Gangamopteris* and other plant remains in Godwin-Austen's typical section near Zewan, about 9 miles south-east of Srinagar. In this section the trap-flows are covered with apparent physical conformity by an oolitic limestone, which has been made crystalline and largely converted into novaculite (*infra*). Above the limestones are beds of siliceous shales covered conformably by the *Gangamopteris*-bearing beds, which pass up through a perfectly conformable series, about 150 feet thick, to limestones containing *Protoretepora ampla* Lonsd., near the base of the Zewan series of Productus limestones. The Protoretepora beds are without doubt the equivalents of the Fenestella shales of Spiti, and are therefore of Upper Carboniferous age, giving the upper limit of age for the *Gangamopteris*-bearing beds. We have thus at last obtained positive proof of the existence of this characteristic Lower Gondwana plant in rocks that cannot be younger in age than the English Coal Measures, and are possibly even Middle Carboniferous in age. As *Gangamopteris* occurs in the lowermost beds of our Gondwana system, the long-disputed contention of the Geological Survey of India as to the Palæozoic age of the Lower Gondwanas is finally settled by positive evidence; and, though other workers have been so near discovering the one link wanting, the honour of completing the chain of evidence belongs to Mr. Hayden.

Silicification and crystallization of oolitic limestone.

106. During his examination of this area Mr. Hayden collected some data of considerable petrographical interest near the junction of the volcanic series and overlying strata, showing in some parts the development of crystalline limestone and in other places of a novaculite from an originally oolitic limestone. The metasomatic replacement of the calcite by silica can be traced through all stages to the formation of a black chert, and while the preservation of the oolitic structure is surprisingly complete, it is still more surprising to find a perfect oolitic appearance in a crystalline limestone coarse

enough in grain to show large glistening facets of calcite crystals on the freshly broken surface of the rocks.

The silicification extends to the shales in the same series, but does not reach the beds containing *Protoretepora ampla* found near the base of the Zewan stage, and appears to have taken place concurrently with the deposition of the Gangamopteris series; it may therefore represent the solfataric stage of the later Palæozoic volcanic period of Kashmir.

Physical conformity of Carboniferous, Permian, and Triassic beds.

107. There are no direct evidences of physical unconformity either above or below the Gangamopteris series, but Mr. Oldham has already drawn attention to certain peculiarities in the Vihi sections which may indicate a break of continuity, though not necessarily any great time interval, between the last trap outflow and the deposition of the Gangamopteris series (*Rec. Geol. Surv. Ind.*, XXXI, 8). There is no indication of unconformity between the upper beds of this series and the base of the Zewan stage either at Zewan or in the Guryul ravine near Khunmu, and it is considered probable that there is no great difference in age between the two.

108. A further discovery of some interest is the presence of beds lithologically not unlike, and containing the same fauna as, the Productus shales of the Himálaya; these occur in the Guryul ravine near Khunmu and also near Mandakpal on the opposite side of the Vihi plain. In the former locality they are covered by a series of thin-bedded limestone and shale containing Lower Triassic fossils, and conforming remarkably in lithological characters to the Himálayan facies of that series; this again is overlaid by a mass of limestone probably representing the Muschelkalk. The whole of this series is found on the Guryul section, where there is a gradual passage from the Protoretepora horizon of the Zewan stage, through the Productus shales and Lower Trias, up to the supposed Muschelkalk. The great Upper Palæozoic unconformity, which has hitherto been regarded as the most marked and persistent feature of Himálayan stratigraphy, is thus absent in this part of Kashmir. Mr. Hayden's results will be published as a separate paper in the *Records*.

T. H. HOLLAND, *Director,*
Geological Survey of India.

CALCUTTA:
January 1st, 1907.

NOTE ON THE DISTRIBUTION OF THE GENERA *Orthophragmina* AND *Lepidocyclina* IN THE NUMMULITIC SERIES OF THE INDIAN EMPIRE. BY ERNEST W. VREDENBURG, A.R.S.M., A.R.C.S.

THE remarkable results arrived at by Messrs. H. and R. Douvillé Lemoine, and the late Mr. Schlumberger, regarding the stratigraphical distribution of the genera *Orthophragmina* and *Lepidocyclina* having been widely challenged of late, especially in Italy,[1] it may be of interest to state the precise circumstances so far observed in various parts of the Indian Empire such as Balúchistán and Sind and the Arakan Yoma where the regularity of the Jura-like disposition of the strata is particularly favourable for clearly establishing the stratigraphical sequence.

In a previous communication (*Rec. Geol. Surv. Ind.*, XXXIV, pp. 79-95) I have indicated the distribution of the nummulites, the lepidocyclines being referred to only incidentally. In this article, the marine Tertiary was divided into four principal groups separated from one another by stratigraphical gaps. These are the Ranikot, Laki, Khirthar, and the Pegu or Mekran system. The latter includes three sub-divisions, the Nari, Gáj, and Hingláj. Nummulites first become abundant in the upper beds of the Upper Ranikot, the leading species being *N. planulatus*. The Laki is characterised by *N. atacicus* and *Assilina granulosa*; it also contains *N. irregularis* and, in its upper zones, a small variety of *A. exponens*. The Lower Khirthar contains *N. irregularis*, *N. lævigatus*, *N. perforatus*, and *A. exponens*. The Middle Khirthar contains the zones richest in nummulites with *N. Murchisoni*, *gizehensis*, *Beaumonti*, *discorbina*, *perforatus*, *Douvillei*, *A. exponens* and *spira*. The Upper Khirthar is a massive limestone, the lower zones of which contain *N. perfor-*

[1] A. Silvestri, Sulla *Lepidocyclina marginata* Michelotti, *Atti Pontif. Acad. Nuovi Lincei*, LIX, pp. 146-166, Rome, 1906; Dr. Checchia-Rispoli, Di alcune Lepidocicline eoceniche della Sicilia, *Riv. ital. Pal.*, XII, pp. 86-92, Peruggia, 1906; F. Sacco, Sur la valeur stratigraphique des Lepidocyclina et des Miogypsina, *Bull. Soc. Géol. Fr.*, (4) V, pp. 880-892, Paris, 1906.

atus and *A. spira,* while the upper ones are generally characterised by *N. complanatus.* The Lower Nari is characterised by *N. intermedius* and *vascus*, and is the last horizon containing large or medium nummulites. The Upper Ranikot is regarded as Upper Ypresian (Cuisian), the bulk of the Laki and Khirthar as Lutetian, the Lower Nari as Stampian, the Upper Nari and Gáj as Aquitanian, the Hingláj as principally Burdigalian.

The greatest stratigraphical gap is between the Khirthar and Nari, and is often accompanied by erosion and dip unconformity. The zone of *N. complanatus* is only locally preserved, and the Nari is frequently observed resting directly on the Middle or Lower Khirthar, or even on the Laki. This widespread unconformity largely accounts no doubt for the palæontological distinctness between the Eocene and Oligocene in India. The genera *Orthophragmina* and *Lepidocyclina* have never been met with together. *Lepidocyclina* characterises the Nari and Gáj, and, in the Arakan Yoma (and its continuation, the Andaman group), some strata corresponding with the base of the Hingláj. *Orthophragmina* occurs in great abundance throughout the Laki, the Lower and Middle Khirthar, and the lower zones of the Upper Khirthar, those containing *Assilina spira*, and *Nummulites perforatus.* In the limestones that I have classified as the third zone of the Upper Khirthar, I have failed to detect any other foraminifer besides *N. complanatus.* The rock seems almost entirely made up of megaspheric and microspheric individuals of this species.

In the article already referred to I have mentioned that in the Mula Pass in Balúchistán, both the Upper Khirthar and Lower Nari are developed to an unusual extent, so much so, that there is perhaps locally a complete passage from the one into the other. Unfortunately both the uppermost Khirthar and lowermost Nari of this interesting locality are represented by massive limestones so hard and compact, and of such uniform texture that it is usually impossible to detect any fossils. They contain several species of nummulites; the only one which I have been able to identify with certainty is *N. intermedius* in the lowermost Nari whose Oligocene age is established by the presence of *Clypeaster*. I made a special search for *Lepidocyclina* and failed to observe any specimens although the genus is well represented in the immediately overlying limestones together with *N. intermedius* and *N. vascus.*

In the same locality I have failed to detect any orbitoides, whether *Orthophragmina* or *Lepidocyclina* in the uppermost Khirthar which I have classified as a fourth zone of the Upper Khirthar, and in which I have observed nummulites doubtfully referable to *N. Brongniarti*, *biarritzensis* and *variolarius*. The uppermost Khirthar and lowermost Nari of the Mula Pass seem to be respectively of Bartonian and Sannoisian age, but in the absence of both *Orthophragmina* and *Lepidocyclina*, this local exposure does not prove anything regarding the distribution of the orbitoides in these two horizons.

Nevertheless, the facts observed in India are difficult to reconcile with the statements made by several eminent observers as to the simultaneous occurrence of *Lepidocyclina* and of typically Lutetian species such as *N. lævigatus*. As already mentioned, the orbitoides associated with *N. lævigatus* and other Khirthar forms, all belong to the genus *Orthophragmina*. It may not be out of place here to mention that, in making collections of foraminifera, it is most important to guard oneself against some very frequent chances of error, such as those resulting from unconformable contacts, overfolds, and derived fossils. To illustrate this, I will here give an account of two particular instances that came under my notice while surveying in Balúchistán.

On one occasion, towards the end of 1905, in the Shírínáb valley to the north of Kelát, I was engaged, together with my colleague Mr. Tipper, in collecting specimens from some shales or clays of Oligocene age (Lower Nari), crowded with *Nummulites intermedius*. The beds are situated on the eastern side of a range running approximately north and south, made up principally of Liassic crinoidal limestones. The Oligocene shales at the place in question dip towards the range, the structure being overfolded. I soon noticed that there were specimens of a small species of *Orthophragmina* scattered amongst the Oligocene nummulites, and apparently weathered out of the same bed. The presence of some specimens of the typical Laki form *Assilina granulosa* finally made it evident that fossils from two different horizons were abnormally associated. In following the strike of the range a section was found clearly showing some shales of the Laki series apparently resting on the Nari shales as the consequence of an overfold, and in some places a continuous ascending succession may be seen consisting of Oligocene, Eocene, Lower Cretaceous, and Lias, the whole series being inverted.

The flysch-like facies of both the Laki and Nari shales is so similar that in this section, as in many others, it is impossible to detect an exact line of junction. The confusion in the Shírínáb section is due partly to a combination of overfolding and unconformity, partly also to the fact that some of the fossils are evidently derived: a beautifully preserved specimen of a small Liassic *Rhynchonella* was found apparently *in situ* amongst the Oligocene nummulites, at a considerable distance from the outcrop of the Lias. I failed to trace the bed from which it must have been weathered out of the Liassic rocks in Oligocene times.

Such a pronounced overfolded structure is somewhat exceptional in Balúchistán, but it is very frequent, I believe, in the Apennines, and when the beds associated with one another are not so distinctly contrasted in geological age as in the case of the Shírínáb section, the most careful observer might easily be led to erroneous conclusions.

Again, in the Oligocene flysch (Kojak Shales) of the Mekran province, in a calcareous sandstone containing *Lepidocyclina* and a large *Heterostegina*, I was surprised on one particular occasion to find, embedded in the same rock, some large specimens of the globose nummulite which I have referred to *N. perforatus*, a species occurring at almost all horizons of the Khirthar. A continued search revealed their presence also inside some limestone pebbles included in the same sandstone. In this case, therefore, the nummulites were derived. Considering the readiness with which certain nummulitic rocks break up into what might be called a nummulitic sand or gravel, it is not surprising that detached specimens should travel just like ordinary pebbles, and thus become embedded in conglomerates and pebbly layers.

I may mention that amongst the old collections of the Calcutta Museum, there are numerous lots containing a promiscuous association of foraminifera characteristic of many different horizons. When studying the nummulites, I have made use of these old collections mainly for morphological purposes, depending mostly on my own field-work for the stratigraphical distribution.

There are innumerable instances, in Sind especially, in which beds of widely different age come into immediate contact with one another without any apparent unconformity, so that their fossils are inevitably associated together on the weathered surface of junction. The confusion observed in the collections does not cast any reflection upon the work of our predecessors who were all under the impression that the strata in Sind represented an uninterrupted conformable sequence. It is only lately that the stratigraphical gaps so obscurely indicated have been made evident and have induced us to be exceptionally cautious in our collections. It is of late years also that one has come to realise the great importance of the foraminifera in stratigraphy.

Owing to the ease with which, under the influence of denudation, specimens of foraminifera from different horizons are apt to be spread all over the hill slopes, it is probable that they are promiscuously associated in many collections made in former days, from various parts of the world. It is probable that the Calcutta Museum is not singular in this respect. In any case, great caution is needed in framing stratigraphical conclusions from the study of these old collections.

The principal conclusions so far arrived at regarding the distribution of *Orthophragmina* and *Lepidocyclina* in the Indian region may bebriefly enumerated as follows:—

1. *Orthophragmina* and *Lepidocyclina* have never been found together.
2. The only large or medium nummulites found with *Lepidocyclina* are *N. intermedius* and *vascus*.
3. There is almost always a very wide stratigraphical gap between the Eocene and Oligocene.
4. In almost every section, *Orthophragmina* occurs up to the top of the Eocene, and *Lepidocyclina* from the very base of the Oligocene so far as these series are developed.
5. In the Mula Pass, both the Eocene and Oligocene are more developed than usual, and there may be locally a passage from one to the other. In this locality, the uppermost beds of the Eocene contain nummulites difficult to identify, perhaps of Bartonian age, while the lowermost beds of the Oligocene are characterised by *N. intermedius* and by *Clypeaster*, but do not contain *Lepidocyclina*, orbitoides being absent both from the uppermost Eocene and the lowermost Oligocene in this particular instance.

6. There are no lepidocyclines answering to the description either of *L. Mantelli* or *L. Raulini.*
7. All the lepidocyclines observed with *N. intermedius* and *vascus* belong to the group of *L. dilatata* with narrow pillars and a megasphere entirely surrounded by the second chamber. *L. dilatata* exclusively characterises the Nari, both Lower and Upper. It is Carter's *Orbitolites Mantelli.*
8. The Gáj contains no large nummulites and is characterised by lepidocyclines often of large dimensions, belonging exclusively to the group of *L. marginata* with large pillars and a megasphere only partly enveloped by the second chamber.
9. The Gáj beds are probably uppermost Aquitanian. Both in Balúchistán and Burma, they are succeeded by undoubtedly Burdigalian beds. In these the presence of small nummulites identical with *N. Niasi* has been detected by H. Douvillé and by Dr. Buxtorf in Burma. Mr. Tipper has observed the same beds in the Andamans where they contain *Nummulites Niasi*, *Amphistegina Niasi*, and numerous small lepidocyclines.
10. The genus *Miogypsina* has not yet been detected in India.

The evidence so far gathered in India supports Douvillé's conclusions and probably holds good for other countries where there is a similar gap between the Eocene and Oligocene. In countries where the intervening stages are better developed, it is quite possible that one may observe an association of the two genera *Orthophragmina* and *Lepidocyclina:* if at any place the first appearance of *Lepidocyclina* preceded the final extinction of *Orthophragmina,* both genera might naturally be found in the same bed. There is reason to believe that such an association does not occur below the summit of the Lutetian, or above the base of the Oligocene.

NOTE ON THE METEORIC SHOWER OF THE 22ND OCTOBER 1903, AT DOKACHI AND NEIGHBOURHOOD, DACCA DISTRICT, BENGAL.

BY L. LEIGH FERMOR, A.R.S.M., B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 1—3.)

The meteoric phenomena.

ON the evening of the 22nd October 1903, at about 7 o'clock local time, an exceptionally bright meteor was seen in Calcutta above the north-eastern horizon. The following extracts from a letter by Mr. C. Little, published in the "Englishman" of 20th November 1903, indicate the unusual interest and importance of this meteor :—

"Since the publication of my letter about the meteor of the 22nd October in your journal and others, I have received many letters from different parts of Bengal, and not a few from Assam, one from distant Sibsagar. The information given in these letters, some of it with unexpected precision as the result of careful measurements made the following day, is sufficient to indicate with fair accuracy the path of the meteor from the time it began to glow dimly as it entered the very attenuated atmosphere at a distance of 120 to 150 miles from the earth's surface until the remnant of it dissipated in the intense heat caused by the thicker atmosphere at a distance of ten or twenty miles from the earth's surface."

The following was the track provisionally adopted from the information obtained :—

"If a line be drawn from Faridpur to a point about 150 miles vertically above Comilla, that line will give with fair accuracy the path of the meteor. It began to glow faintly before it was vertically over Daudkhandi and in two or three seconds after that about the time it was over the water it became brightly illuminated. It then attracted attention over a wide area, including the whole of Bengal and Assam. It must have been seen in Upper Burma over the north of the Bay of Bengal and over a considerable portion of Central India. Information has reached me from Orissa, Chota Nágpur, Tirhoot, the Darjeeling Hills, and, as already mentioned, Sibsagar, and I may still hear from Burma. The angular elevations reported to me from various more or less distant places show that when the meteor began to attract general attention it must have been at a height of 100 miles, and that during the subsequent 15 seconds it descended at a diminishing speed to within 10 or 20 miles. It then broke up."

"The excitement in East Bengal was great, the intense light and loud sounds resembling the reports of cannon were observed over a wide area, and when it is remembered that in such an unusual occurrence experience is of little assistance, it is not surprising that most people should have thought that something terrible was happening in their own immediate neighbourhood."

As the result of inquiries initiated by the Geological Survey of India, it was found that a regular shower of meteoric stones had fallen about 150 miles north-east of Calcutta in the Munshiganj sub-division of the Dacca district. The most interesting points, therefore, in connection with this meteor are—(1) the great height at which it became visible, (2) the steeply inclined path, and (3) the shower of stones which fell in the above-mentioned area.

The collection of specimens.

Mr. J. T. Rankin, Collector of Dacca, kindly interested himself in the matter and collected as many of these stones —14 in all—as could be obtained, and forwarded them to the Geological Survey, together with a certain amount of information relative to the circumstances of their fall.

Three of the largest specimens obtained—A 1, A 2, and A 3—were collected at Dokáchi and forwarded by Raja Srinath Roy of Bhagyakul, who generously presented two of them to the Geological Museum. During the past year (1906) Mr. H. E. Stapleton, Inspector of Schools, Dacca Division, has, while touring in this part of India, made exhaustive enquiries amongst the villagers, which have resulted in the acquirement by him of 7 stones, namely, Nos. C 7, F 4 to F 7, H and J. These are at present deposited with the Geological Survey and will be afterwards presented to the Oxford Museum.

The locus of the fall.

The following are the villages within which stones are recorded to have fallen: Bangáon, Bibandi, Dakhin Paikshar, Dokáchi, Háriya, Kolapára, Kukutiya, Munshiya and Rána. They lie in the Srinagar thána, through whose Sub-Inspector of Police Mr. Rankin obtained most of the specimens.

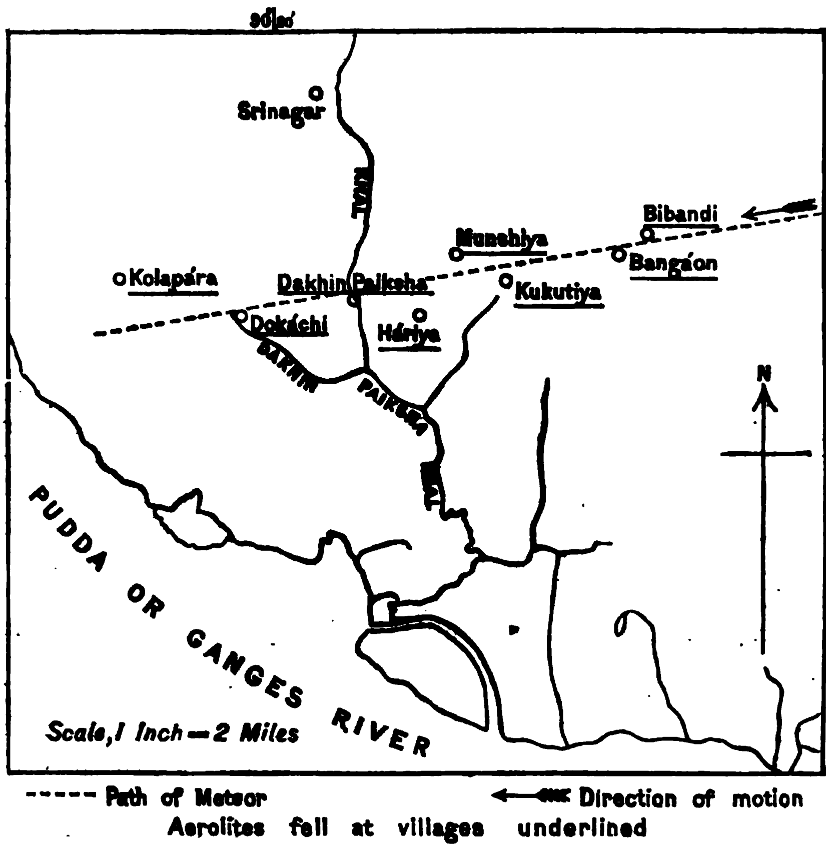

FIG. 2.—Sketch-map of the area of the Dokáchi fall.

As will be seen from the accompanying sketch-map (fig. 2), these villages lie more or less in a straight line, which stretches west by a little south from Bibandi[1] on the east, to Kolapára (Konapara on the old 1-inch map of this area) about two miles from the left bank of the Ganges on the west—a total distance of 6 miles. No stones are known to have fallen in the Faridpur district on the opposite bank; and

[1] Since this woodcut was prepared, Mr. Stapleton has obtained a specimen from Rána which lies about half a mile south-east of Bibandi.

although it is improbable that any so fell, it is possible that some of the aërolites found a resting-place at the bottom of the Ganges.[1]

Phenomena attending the fall.

Raja Srinath Roy, who was an eye-witness of the fall, relates that after a few streaks of light—perhaps due to some smaller fragments accompanying the main mass of the meteorite—and a noise as of cannons "came a streak of blue light and the meteorite burst, apparently straight over the village of Dokáchi, with a dazzling light that lit up all the surrounding villages." The morning after the fall the Raja sent men to Dokáchi, where they collected a basketful of small fragments, which he, not knowing the scientific value of these objects, allowed to be carried away, keeping only the three large fragments previously mentioned. These three weigh in the aggregate 2,360 grammes out of a total weight of 3,838 grammes received. The greater portion of the meteorite, therefore, seems to have fallen at Dokáchi, in consequence of which it is proposed to attach the name of this village to the fall. Dokáchi is 17 miles south-south-west of Dacca; its bearings are 23° 30′ N. latitude and 90° 20′ E. longitude.

In a letter from Mr. H. F. T. Maguire, Deputy Collector in Charge, Dacca, it is stated that the Sub-Inspector of Police of Srinagar reported "that all the fragments were found cold when picked up on the following morning, that a thundering sound in the distant horizon, lasting about ½ a minute, was heard a little after the disappearance of the flashing light, and that the largest of the 4 fragments received by him[2] . . . is said to have been found ¾ of an inch under the earth and that it carried away along with it a branch of a tree as thick as the middle finger of a man and also a portion of the bark of a tree with which it came in contact."

Weights of the specimens obtained.

The weights of the various fragments obtained are shown in the following table, where the numbers given in the third column are those assigned to the various specimens in the Geological Survey register:—

[1] From the considerations put forward on page 74 it will be seen that if any fragments fell into the Ganges, they were probably of still larger size than those of Dokáchi and Kolapára, and that, following the same line of argument, had any fallen in the Faridpur district, they would have been so large that they could scarcely have escaped detection.

[2] No. 240 B, from Kolapára. The other three referred to are 240 C 2, 240 C 3, and 243 C 5 which fell at Dakhin Paiksha. Only four fragments had been recovered when this letter was written.

TABLE I.—*Weights of the Aërolites.*

Village.	Where found.	Registered number of specimen.	Weight in grammes.	Total weight received from each village.	Specific gravity.
A.—Dokáchi	See above	240 A 1	1570·99		3·62
		240 A 2	594·04		3·62
		240 A 3	195·35	2360·38	
B.—Kolapára	House of Monohari Mandal	240 B	627·39	627·39	3·65
C.—Dakhin Paiksha[1]	House of Shaikh Ibrahim	240 C 1	80·90		
	Picked up in village	240 C 2	37·84		
	Do. do.	240 C 3	28·93		
	House of Safar Ali Mirdha	240 C 4	28·51		
	Picked up in village	240 C 5	25·17		
	House of Ruponanda Mandal[2]	240 C 6	15·76		
	Picked up in village[3]	240 C 7	486·18	703·29	
D.—Kukutiya	House of Jagir Khan	240 D	29·98	29·98	
E.—Munshiya[4]	House of Taripulla	240 E	6·74	6·74	

[1] Stones also fell one in each of the houses of Rupchand Kuri, Jamiruddin, Sib Chandra Bachor, Nayan Khan, and Kali Charan Barar, but could not be obtained.

[2] It is doubtful whether the specimen received was this or the one which fell in the house of Rupchand Kuri. C 4 and C 6 fit together along a fractured surface which is undoubtedly artificial; hence they could not have been found in two different houses as reported.

[3] This stone was recently (1906) obtained for Mr. Stapleton by Rajendra Mandal, a *namasudra* of Satghoria, from an aunt of his at Dakhin Paiksha. It was for some time worshipped, and traces of the *sindur* or vermilion paint with which it was smeared are still left on the specimen.

[4] Another piece is said to have fallen in the house of Kadir Munshi. That received was broken into four fragments.

TABLE I.—*Weights of the Aërolites*—contd.

Village.	Where found.	Registered number of specimen.	Weight in grammes.	Total weight received from each village.	Specific gravity.
F.—Bibandi [1] .	House of Khas Mahmud .	240 F 1	5·29		
	Do. Shaikh Safar Ali .	240 F 2	2·33		
	Do. Ambica Charan Japadar.	240 F 3[2]	0·73		
	Do. Harish Chandra Mullick.	240 F 4	9·03		
	Do. do. .	240 F 5	1·97		
	Do. do. .	240 F 6	1·76		
	Do. do. .	240 F 7	1·32	22·43	
G.—Bangáon .	House of Shaikh Roshan .	240 G 1	2·88		
	Do. Shaikh Charu .	240 G 2	1·38	4·26	
H.—Háriya [3] .	House of Mehari Mollah .	240 H	66·18	66·18	
J.—Rána [4] .	Picked up in village . .	240 J	17·79	17·79	

Total weight received = 3838·44 grammes.

The number of aërolites.

Although but 24 fragments of this fall have reached the Geological Survey, it is clear that the number of stones found in the various villages named above must have been at a minimum almost a hundred; and if the open spaces between the villages from which no stones have been reported be considered, it is evident that the number of aërolites

[1] Here also "about 25 pieces as black as coal are said to have fallen like hailstones on the tin sheds in the house of one Haris Chandra Mullick, but they have all been taken to Tipperah" and "it is said that about 15 or 16 pieces had fallen in the house of one Ananda Chandra Chakravarti, of which 4 pieces were found and taken by others." Mr. Stapleton has recently (1906) obtained 4 pieces (F 4 to F 7), which were given to his circle-pundit by the villagers, who said that they had picked them up after they rebounded from the corrugated iron roof of the house of Harish Chandra Mullick, who is now dead. Mr. Stapleton has, however, been unable to trace the 25 pieces which were taken to Comilla in Tipperah.

[2] Two pieces fitting together.

[3] This piece was recently (1906) obtained by Mr. Stapleton from the aunt of Mehari Mollah of Háriya and is one of the three pieces reported by the police to have fallen on his house.

[4] This was obtained by Mr. Stapleton in November 1905 from a writer-constable of Rána, who had himself picked it up at Rána.

which reached the earth's surface must have been numbered by the hundred.

In Table II the villages are arranged in order from west to east along the line of flight. It will be seen from the second column that the total weight in grammes of the meteorite recovered from each village evidently depends roughly on the position of the village. On grouping the villages into pairs this relation becomes clearer and it is seen that the total weight recovered from each pair, as shown by the third column of the following table, is greater the nearer is the pair of villages situated along the line of flight to the Kolapára end :—

The distribution of the meteoritic fragments along the line of fall.

TABLE II.

	Villages in order from west to east.	Total weight of meteorite received from each village.	Total weight of meteorite received from each pair of villages.
⟵ Direction of flight.	Kolapára	627·39	2987·77
	Dokáchi	2360·38	
	Dakhin Paiksha	703·29	769·47
	Háriva	66·18	
	Munshiya	6·74	36·72
	Kukutiya	29·98	
	Bangáon	4·26	26·69
	Bibandi	22·43	
	Rána	17·79	17·79

It is interesting that what is evidently but a portion of the total fall should indicate what one would *à priori* expect, namely, that after the break-up of the primitive meteoritic body, the fragments of greater mass, and consequently, on the average, those possessing the greater momentum, being better able to overcome the resistance of the atmosphere, travelled further in the original direction of motion of the meteor before reaching the surface of the earth, than those of lesser mass. Without knowing the values of the kinetic energy per unit mass of the primitive meteor just before disruption and of the kinetic energy per unit mass imparted to the fragments at the time of disruption, it is impossible to say whether any fragment was carried backwards so as to reach the earth at a point east of that over which the disruption took place. Consequently we cannot say whether the disruption took place at a point immediately over or to the east of Bibandi (see map, fig. 1), or whether it occurred over some point intermediate between Bibandi and Dokáchi. In the latter eventuality the point of disruption was no doubt much nearer the eastern than the western end of the line joining Bibandi to Dokáchi.

Description of the specimens.

The three plates accompanying this note are from photographs taken by Mr. Vredenburg, and show one or more views of each of the fragments received.[1] The majority of the aërolites are more or less completely covered with a dull to slightly glossy crust varying in colour from brownish-black to black.

Crust.

Numbers 240 A 1 and 240 A 3 each have a few small patches of greyish-white and of rusty colour superposed upon the black crust. The crust of 240 A 2 and 240 F 1 is complete, so that each of these is a perfect aërolite; of that of numbers 240 A 1, 240 A 3, 240 B, 240 C 1, 240 C 2, 240 C 7, 240 F 2, 240 F 4 to 240 F 7,[2] 240 G 1, 240 G 2, and 240 H only small portions are lacking; whilst the remainder have lost a fair proportion of their crust. This is usually comparatively smooth, but often exhibits numerous small pimples and ridges of a shining black colour; they impart a slight polish to those stones on which they occur in any abundance, as in the Kolapára specimen, 240 B. With a lens it is seen that the space between the elevations on the surface of this stone is minutely granulated.

Pittings.

"Pittings" or "thumb marks" are well represented in some of the stones—especially in the Dokáchi and Dakhin Paiksha specimens, 240 A 1 and 240 C 1, respectively. Those of 240 A 1 are well shown in Plate 1.

[1] Except the seven obtained by Mr. Stapleton after these plates had been prepared.

[2] 240 F 6 is practically a perfect aërolite although it only weighs 1·76 grammes.

Slickensiding.

Good examples of "slickensiding" are seen on one surface of 240 A 2 (see Plate 1), in 240 C 6, and to a small extent in 240 C 4. The slickensided surface of 240 C 6 is polished and somewhat striated and has a metallic lustre. It is really one side of a fracture—made by human agency since the fall—which has followed a thin black veinlet traversing the specimen. When examined with a lens, the shining appearance is seen to be due to a thin, more or less continuous, layer of metallic aspect—perhaps nickeliferous iron—forming the vein. The slickensided area of 240 A 2 was possibly caused by a fragment splitting off during flight, as it has not the appearance of being due to a blow.

Fracture during flight.

At one end of the Kukutiya stone, 240 D, is a concave fractured surface (see Plate 3) which must have been produced during the flight of the aërolite while it was still travelling with considerable speed; for this surface shows a partially formed new crust of younger age than that covering the rest of the stone, indicating that it was subjected to partial fusion posterior to fracture.

Character of the fractures.

Some of the specimens show fractures which have every appearance of being quite fresh, and which were no doubt made by the people by whom they were found. The colour of these fractures is pale ash-grey, and examined with a lens, the stone is seen to contain darkish-grey, more or less rounded bodies, which are presumably chondri, and are set in a grey and white matrix. There are also abundant scattered yellowish-white metallic points and granules of metal—presumably nickeliferous iron. Several of the specimens show one or more black veins as thin as a sheet of paper, which, when fractured, show the "metallic" slickensided surfaces referred to above.

Specific gravity.

The value of the specific gravity was determined as 3·63, this being the mean of the three values shown in Table I. The stones are so porous that at least 2 days' soaking is necessary to obtain even an approximately correct value. Since soaking in water for this length of line caused the specimens to rust, it was not considered desirable to determine the value of this constant for them all.

No chemical or microscopic investigation of this meteorite has been attempted, as the object of this note is merely to put on record, while the specimens are all together, a short account of the circumstances attending the fall, together with a description of the stones, as far as their external characteristics go.

Distribution of the specimens.

Since writing the above, some of the fragments of this meteorite have been presented as follows:—

(1) 240 A 2 and 240 C 4 to the British Museum.
(2) 240 C 1 to the Museum d'Histoire Naturelle, Paris.
(3) 240 C 2 to His Royal Highness Prince Edward of York.
(4) 240 C 3 to the K. K. Naturhistorisches Hofmuseum, Vienna.
(5) 240 A 3 was presented by the Raja Srinath Roy of Bhagyakul to Mrs. Goodburn of Shillong. This specimen has lately been taken to England.

The seven specimens—240 C 7, 240 F 4 to 240 F 7, 240 H, 240 J—obtained by Mr. Stapleton, will be presented by him to the Oxford Museum.

The Kolapára specimen—240 B—has been sliced by the late Professor Ward, who retained a slice weighing 193 grammes, while the remaining five slices, weighing in all 396 grammes (38 grammes having been lost on sectioning), together with the ten other pieces not mentioned above, are still in the possession of the Geological Survey of India.

The present distribution of this meteorite is therefore as follows:—

	Grammes.
Geological Survey of India	2057·35
British Museum	622·55
Oxford Museum	584·23
Mrs. Goodburn	195·35
Professor Ward	193·
Paris Museum	80·90
H. R. H. Prince Edward of York	37·84
Vienna Museum	28·93
	3800·15
Less on cutting	38·3
	3838·45

It is to be hoped that one of the possessors of parts of this fall will supplement this paper by making a chemical and mineralogical examination of this interesting meteorite.

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Part 3.—Note on the progress of the gold industry in Wynaad, Nilgiri district. Notes on the representatives of the Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

Part 4.—On the geographical distribution of fossil organisms in India. Submerged forest on Bombay Island.

Vol. XII, 1879.

Part 1.—Annual report for 1878. Geology of Kashmir (third notice). Further notices of Siwalik mammalia. Notes on some Siwalik birds. Notes of a tour through Hangrang and Spiti. On a recent mud eruption in Ramri Island (Arakan). On Braunite, with Rhodonite, from near Nagpur, Central Provinces. Palæontological notes from the Satpura coal-basin. Statistics of coal importations into India.

Part 2.—On the Mohpani coal-field. On Pyrolusite with Psilomelane occurring at Gosalpur, Jabalpur district. A geological reconnaissance from the Indus at Kushalgarh to the Kurram at Thal on the Afghan frontier. Further notes on the geology of the Upper Punjab.

Part 3.—On the geological features of the northern part of Madura district, the Pudukota State, and the southern parts of the Tanjore and Trichinopoly districts included within the limits of sheet 80 of the Indian Atlas. Rough notes on the cretaceous fossils from Trichinopoly district, collected in 1877-78. Notes on the genus Sphenophyllum and other Equisetaceæ, with reference to the Indian form Trizygia Speciosa, Royle (Sphenophyllum Trizygia, Ung.). On Mysorin and Atacamite from the Nellore district. On corundum from the Khasi Hills. On the Joga neighbourhood and old mines on the Nerbudda.

Part 4.—On the 'Attock Slates' and their probable geological position. On a marginal bone of an undescribed tortoise, from the Upper Siwaliks, near Nila, in the Potwar, Punjab. Sketch of the geology of North Arcot district. On the continuation of the road section from Murree to Abbottabad.

Vol. XIII, 1880.

Part 1.—Annual report for 1879. Additional notes on the geology of the Upper Godavari basin in the neighbourhood of Sironcha. Geology of Ladak and neighbouring districts, being fourth notice of geology of Kashmir and neighbouring territories. Teeth of fossil fishes from Ramri Island and the Punjab. Note on the fossil genera Nöggerathia, Stbg., Nöggerathiopsis, Fstm., and Rhiptozamites, Schmalh., in palæozoic and secondary rocks of Europe, Asia, and Australia. Notes on fossil plants from Kattywar, Shekh Budin, and Sirgujah. On volcanic foci of eruption in the Konkan.

Part 2.—Geological notes. Palæontological notes on the lower trias of the Himalayas. On the artesian wells at Pondicherry, and the possibility of finding such sources of water-supply at Madras.

Part 3.—The Kumaun lakes. On the discovery of a celt of palæolithic type in the Punjab. Palæontological notes from the Karharbari and South Rewah coal-fields. Further notes on the correlation of the Gondwana flora with other floras. Additional note on the artesian wells at Pondicherry. Salt in Rajputana. Record of gas and mud eruptions on the Arakan coast on 12th March 1879 and in June 1843.

Part 4.—On some pleistocene deposits of the Northern Punjab, and the evidence they afford of an extreme climate during a portion of that period. Useful minerals of the Arvali region. Further notes on the correlation of the Gondwana flora with that of the Australian coal-bearing system. Note on reh or alkali soils and saline well waters. The re-soils of Upper India. Note on the Naini Tal landslip, 18th September 1880.

Vol. XIV, 1881.

Part 1.—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts, being fifth notice of the geology of Kashmir and neighbouring territories. Note on some Siwalik carnivora. The Siwalik group of the Sub-Himalayan region. On the South Rewah Gondwana basin. On the ferruginous beds associated with the basaltic rocks of north-eastern Ulster, in relation to Indian laterite. On some Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on the lower trias of the Himalayas.' On some mammalian fossils from Perim Island, in the collection of the Bombay Branch of the Royal Asiatic Society.

Part 2.—The Nahan-Siwalik unconformity in the North-western Himalaya. On some Gondwana vertebrates. On the ossiferous beds of Hundes in Tibet. Notes on mining records, and the mining record office of Great Britain; and the Coal and Metalliferous Mines Acts of 1872 (England). On cobaltite and danaite from the Khetri mines, Rajputana; with some remarks on Jaipurite (Syepoorite). On the occurrence of zinc ore (Smithsonite and Blende) with barytes, in the Karnul district, Madras. Notice of a mud eruption in the island of Cheduba.

Part 3.—Artesian borings in India. On oligoclase granite at Wangtu on the Sutlej, North-west Himalayas. On a fish-palate from the Siwaliks. Palæontological notes from the Hazaribagh and Lohardagga districts. Undescribed fossil carnivora from the Siwalik hills in the collection of the British Museum.

Part 4.—Remarks on the unification of geological nomenclature and cartography. On the geology of the Arvali region, central and eastern. On a specimen of native antimony obtained at Pulo Obin, near Singapore. On Turgite from the neighbourhood of Juggiapett, Kistnah district, and on zinc carbonate from Karnul, Madras. Note on the section from Dalhousie to Pangi, *viâ* the Sach Pass. On the South Rewah Gondwana basin. Submerged forest on Bombay Island.

Vol. XV, 1882.

Part 1.—Annual report for 1881. Geology of North-west Kashmir and Khagan (being sixth notice of geology of Kashmir and neighbouring territories). On some Gondwana labyrinthodonts. On some Siwalik and Jamna mammals. The geology of Dalhousie, North-west Himalaya. On remains of palm leaves from the (tertiary) Murree and Kasauli beds in India. On Iridosmine from the Noa-Dihing river, Upper Assam, and on Platinum from Chutia Nagpur. On (1) a copper mine lately opened near Yongri hill, in the Darjiling district; (2) arsenical pyrites in the same neighbourhood; (3) kaolin at Darjiling (being 3rd appendix to a report on the geology and mineral resources of the Darjiling district and the Western Duars). Analyses of coal and fire-clay from the Makum coal-field, Upper Assam. Experiments on the coal of Pind Dadun Khan, Salt-range, with reference to the production of gas, made April 29th, 1881. Report on the proceedings and result of the International Geological Congress of Bologna.

Part 2.—General sketch of the geology of the Travancore State. The Warkilli beds and reported associated deposits at Quilon, in Travancore. Note on some Siwalik and Narbada fossils. On the Coal-bearing rocks of the valleys of the Upper Rer and the Mand rivers in Western Chutia Nagpur. On the Pench river coal-field in Chhindwara district, Central Provinces. On borings for coal at Engsein, British Burma. On sapphires recently discovered in the North-west Himálaya. Notice of a recent eruption from one of the mud volcanoes in Cheduba.

Part 3.—Note on the coal of Mach (Much) in the Bolan Pass, and of Sharag or Sharigh on the Harnai route between Sibi and Quetta. New faces observed on crystals of stilbite from the Western Ghâts, Bombay. On the traps of Darang and Mandi in the North-western Himálayas. Further note on the connexion between the Hazara and the Kashmir series. On the Umaria coal-field (South Rewah Gondwana basin). The Daranggiri coal-field, Garo Hills, Assam. On the outcrops of coal in the Myanoung division of the Henzada district.

Part 4.—On a traverse across some gold-fields of Mysore. Record of borings for coal at Beddadanol, Godavari district, in 1874. Note on the supposed occurrence of coal on the Kistna.

Vol. XVI, 1883.

Part 1.—Annual report for 1882. On the genus Richthofenia, Kays (Anomia Lawrenciana, Koninck). On the geology of South Travancore. On the geology of Chamba. On the basalts of Bombay.

Part 2.—Synopsis of the fossil vertebrata of India. On the Bijori Labyrinthodont. On a skull of Hippotherium antilopinum. On the iron ores, and subsidiary materials for the manufacture of iron, in the north-eastern part of the Jabalpur district. On laterite and other manganese ore occurring at Gosulpore, Jabalpur district. Further notes on the Umaria coal-field.

Part 3.—On the microscopic structure of some Dalhousie rocks. On the lavas of Aden. On the probable occurrence of Siwalik strata in China and Japan. On the occurrence of Mastodon angustidens in India. On a traverse between Almora and Mussooree made in October 1882. On the cretaceous coal-measures at Borsora, in the Khasia Hills, near Laour, in Sylhet.

Part 4.—Palæontological notes from the Daltonganj and Hutar coal-fields in Chota Nagpur. On the altered basalts of the Dalhousie region in the North-western Himalayas. On the microscopic structure of some Sub-Himálayan rocks of tertiary age. On the geology of Jaunsar and the Lower Himálayas. On a traverse through the Eastern Khasia, Jaintia, and North Cachar Hills. On native lead from Maulmain and chromite from the Andaman Islands. Notice of a fiery eruption from one of the mud volcanoes of Cheduba Island, Arakan. Notice.—Irrigation from wells in the North-Western Provinces and Oudh.

Vol. XVII, 1884.

Part 1.—Annual report for 1883. Considerations on the smooth-water anchorages or mud banks of Narrakal and Alleppy on the Travancore coast. Rough notes on Billa Surgam and other caves in the Kurnool district. On the geology of the Chuari and Sihunta parganas of Chamba. On the occurrence of the genus Lyttonia, Waagen, in the Kuling series of Kashmir.

Part 2.—Notes on the earthquake of 31st December 1881. On the microscopic structure of some Himalayan granites and gneissose granites. Report on the Choi coal exploration. On the re-discovery of certain localities for fossils in the Siwalik beds. On some of the mineral resources of the Andaman Islands in the neighbourhood of Port Blair. The intertrappean beds in the Deccan and the Laramie group in western North America.

Part 3.—On the microscopic structure of some Arvali rocks. Section along the Indus from the Peshawar Valley to the Salt-range. On the selection of sites for borings in the Raigarh-Hingir coal-field (first notice). Note on lignite near Raipore, Central Provinces. The Turquoise mines of Nishâpûr, Khorassan. Notice of a further fiery eruption from the Minbyin mud volcano of Cheduba Island, Arakan. Report on the Langrin coal-field, south-west Khasia Hills. Additional notes on the Umaria coal-field.

Part 4.—On the Geology of part of the Gangasulan pargana of British Garhwal. On fragments of slates and schists imbedded in the gneissose granite and granite of the North-west Himalayas. On the geology of the Takht-i-Suleiman. On the smooth-water anchorages of the Travancore coast. On auriferous sands of the Subansiri river, Pondicherry lignite, and phosphatic rocks at Musuri. Work at the Billa Surgam caves.

Vol. XVIII, 1885.

Part 1.—Annual report for 1884. On the country between the Singareni coal-field and the Kistna river. Geological sketch of the country between the Singareni coal-field and Hyderabad. On coal and limestone in the Doigrung river, near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field notes.

Part 2.—A fossiliferous series in the Lower Himálaya, Garhwal. On the probable age of the Mandhali series in the Lower Himálaya. On a second species of Siwalik camel (Camelus Antiquus, nobis ex Falc. and Caut. MS.). On the Geology of Chamba. On the probability of obtaining water by means of artesian wells in the plains of Upper India. Further considerations upon artesian sources in the plains of Upper India. On the geology of the Aka Hills. On the alleged tendency of the Arakan mud volcanoes to burst into eruption most frequently during the rains. Analyses of phosphatic nodules and rock from Mussooree.

Part 3.—On the Geology of the Andaman Islands. On a third species of Merycopotamus. Some observations on percolation as affected by current. Notice of the Pirthalla and Chandpur meteorites. Report on the oil-wells and coal in the Thayetmyo district, British Burma. On some antimony deposits in the Maulmain district. On the Kashmir earthquake of 30th May 1885. On the Bengal earthquake of 14th July 1885.

Part 4.—Geological work in the Chhattisgarh division of the Central Provinces. On the Bengal earthquake of July 14th, 1885. On the Kashmir earthquake of 30th May 1885. On the results of Mr. H. B. Foote's further excavations in the Billa Surgam caves. On the mineral hitherto known as Nepaulite. Notice of the Sabetmahet meteorite.

Vol. XIX, 1886.

Part 1.—Annual report for 1885. On the International Geological Congress of Berlin. On some Palæozoic Fossils recently collected by Dr. H. Warth, in the Olive group of the Salt-range. On the correlation of the Indian and Australian coal-bearing beds. Afghan and Persian Field notes. On the section from Simla to Wangtu, and on the petrological character of the Amphibolites and Quartz Diorites of the Sutlej valley.

Part 2.—On the Geology of parts of Bellary and Anantapur districts. Geology of the Upper Dehing basin in the Singpho Hills. On the microscopic characters of some eruptive rocks from the Central Himálayas. Preliminary note on the Mammalia of the Karnul Caves. Memorandum on the prospects of finding coal in Western Rajputana. Note on the Olive group of the Salt-range. On the discussion regarding the boulder-beds of the Salt-range. On the Gondwana Homotaxis.

Part 3.—Geological sketch of the Vizagapatam district, Madras. Preliminary note on the geology of Northern Jesalmer. On the microscopic structure of some specimens of the Malani rocks of the Arvali region. On the Malanjkhandi copper-ore in the Balaghat district, C. P.

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Vol. XX, 1887.

Part 1.—Annual report for 1886. Field-notes from Afghanistan: No. 4, from Turkistan to India. Physical geology of West British Garhwal; with notes on a route traverse through Jaunsar-Bawar and Tiri-Garhwal. On the geology of the Garo Hills. On some Indian image-stones. On soundings recently taken off Barren Island and Narcondam. On a character of the Talchir boulder-beds. Analysis of Phosphatic Nodules from the Salt-range, Punjab.

Part 2.—The fossil vertebrata of India. On the Echinoidea of the cretaceous series of the Lower Narbada Valley, with remarks upon their geological age. Field-notes: No. 5—to accompany a geological sketch map of Afghanistan and North-eastern Khorassan. On the microscopic structure of some specimens of the Rajmahal and Deccan traps. On the Dolerite of the Chor. On the identity of the Olive series in the east with the speckled sandstone in the west of the Salt-range in the Punjab.

Part 3.—The retirement of Mr. Medlicott. Notice of J. B. Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun, Section I. Preliminary sketch of the geology of Simla and Jutogh. Note on the 'Lalitpur' meteorite.

Part 4.—Note on some points in Himálayan geology. Crystalline and metamorphic rocks of the Lower Himálaya, Garhwal, and Kumaun, Section II. The iron industry of the western portion of the District of Raipur. Notes on Upper Burma. Boring exploration in the Chhattisgarh coal-fields. (Second notice.) Some remarks on Pressure Metamorphism, with reference to the foliation of the Himálayan Gneissose Granite. A list and index of papers on Himálayan Geology and Microscopic Petrology, published in the preceding volumes of the Records of the Geological Survey of India.

Vol. XXI, 1888.

Part 1.—Annual report for 1887. Crystalline and metamorphic rocks of the Lower Himálaya, Garhwal, and Kumaun, Section III. The Birds'-nest or Elephant Island, Mergui Archipelago. Memorandum on the results of an exploration of Jessalmer, with a view to the discovery of coal. A facetted pebble from the boulder bed ('speckled sandstone') of Mount Chel in the Salt-range in the Punjab. Examination of nodular stones obtained by trawling off Colombo.

Part 2.—Award of the Wollaston Gold Medal, Geological Society of London, 1888. The Dharwar System, the chief auriferous rock series in South India. On the Igneous rocks of the districts of Raipur and Balaghat, Central Provinces. On the Sangar Marg and Mehowgale coal-fields, Kashmir.

Part 3.—The Manganese Iron and Manganese Ores of Jabalpur. 'The Carboniferous Glacial Period.' The sequence and correlation of the pre-tertiary sedimentary formations of the Simla region of the Lower Himálayas.

Part 4.—On Indian fossil vertebrates. On the geology of the North-west Himalayas. On blown-sand rock sculpture. Re-discovery of Nummulites in Zanskar. On some mica traps from Barakar and Raniganj.

Vol. XXII, 1889.

Part 1.—Annual report for 1888. The Dharwar System, the chief auriferous rock-series in South India. (Second notice.) On the Wajra Karur diamonds, and on M. Chaper's alleged discovery of diamonds in pegmatite near that place. On the generic position of the so-called Plesiosaurus Indicus. On flexible sandstone or Itacolumite, with special reference to its nature and mode of occurrence in India, and the cause of its flexibility. On Siwalik and Narbada Chelonia.

Part 2.—Note on Indian Steatite. Distorted pebbles in the Siwalik conglomerate. The 'Carboniferous Glacial Period.' Notes on Dr. W. Waagen's 'Carboniferous Glacial Period.' On the oil-fields of Twingoung and Beme, Burma. The gypsum of the Nehal Nadi, Kumaun. On some of the materials for pottery obtainable in the neighbourhood of Jabalpur and of Umaria.

Part 3.—Abstract report on the coal outcrops in the Sharigh Valley, Baluchistan. On the discovery of Trilobites by Dr. H. Warth in the Neobolus beds of the Salt-range. Geological notes. On the Cherra Poonjee coal-field, in the Khasia Hills. On a Cobaltiferous Matt from Nepál. The President of the Geological Society of London on the International Geological Congress of 1888. Tin-mining in Mergui district.

Part 4.—On the land-tortoises of the Siwaliks. On the pelvis of a ruminant from the Siwaliks. Recent assays from the Sambhar Salt-Lake in Rajputana. The Manganiferous Iron and Manganese Ores of Jabalpur. On some Palagonite-bearing raps of the Rájmahál hills and Deccan. On tin-smelting in the Malay Peninsula. Provisional index of the local distribution of important minerals, miscellaneous minerals, gem stones and quarry stones in the Indian Empire. Part 1.

Vol. XXIII, 1890.

Part 1.—Annual report for 1889. On the Lakadong coal-fields, Jaintia Hills. On the Pectoral and pelvic girdles and skull of the Indian Dicynodonts. On certain vertebrate remains from the Nagpur district (with description of a fish-skull). Crystalline and metamorphic rocks of the Lower Himálayas, Garhwál and Kumaun, Section IV. On the bivalves of the Olive-group, Salt-range. On the mud-banks of the Travancore coast.

Part 2.—On the most favourable sites for Petroleum explorations in the Harnai district, Baluchistan. The Sapphire Mines of Kashmir. The supposed Matrix of the Diamond at Wajra Karur, Madras. The Sonapet Gold-field. Field Notes from the Shan Hills (Upper Burma). A description of some new species of Syringosphæridæ, with remarks upon their structures, &c.

Part 3.—On the Geology and Economic Resources of the Country adjoining the Sind-Pishin Railway between Sharigh and Spintangi, and of the country between it and Khattan (with a map). Report of a Journey through India in the winter of 1888-89, by Dr. Johannes Walther, translated from the German, by R. Bruce Foote. On the Coal-fields of Lairungao, Maosandram, and Mao-be-lar-kar, in the Khasi Hills (with 3 plans). Further Note on Indian Steatite. Provisional Index of the Local Distribution of Important Minerals, Miscellaneous Minerals, Gem Stones, and Quarry Stones in the Indian Empire (continued from p. 286, Vol. XXII).

Part 4.—Geological sketch of Naini Tal; with some remarks on the natural conditions governing mountain slopes (with a map and plate). Notes on some Fossil Indian Bird Bones. The Darjiling Coal between the Lisu and the Ramthi rivers, explored during season 1890-91 (with a map). The Basic Eruptive Rocks of the Kadapah Area. The Deep Boring at Lucknow. Preliminary Note on the Coal Seam of the Dore Ravine, Hazara (with two plates).

Vol. XXIV, 1891.

Part 1.—Annual report for 1890. On the Geology of the Salt-range of the Punjab, with a re-considered theory of the Origin and Age of the Salt-Marl (with five plates). On veins of Graphite in decomposed Gneiss (Laterite) in Ceylon. Extracts from the Journal of a trip to the Glaciers of the Kabru, Pandim, &c. The Salts of the Sambhar Lake in Rajputana, and of the Saline efflorescence called 'Reh' from Aligarh in the North-Western Provinces. Analysis of Dolomite from the Salt-range, Punjab.

Part 2.—Preliminary Report on the Oil locality near Moghal Kot, in the Sheráni country, Suleiman Hills. On Mineral Oil from the Suleiman Hills. Note on the Geology of the Lushai Hills. Report on the Coal-fields in the Northern Shan States. Note on the reported Namsèka Ruby-mine in the Mainglôn State. Note on the Tourmaline (Schorle) Mines in the Mainglôn State. Note on a Salt-spring near Bawgyo, Thibaw State.

Part 3.—Boring Exploration *in the* Daltongunj Coal-field, *Palamow* (with a map). *Death of* Dr. P. Martin Duncan. Contributions *to the* study *of the* Pyroxenic varieties *of* Gneiss *and of the* Scapolite-bearing Rocks.

Part 4.—On a Collection of Mammalian Bones from Mongolia. Further note on the Darjiling Coal Exploration. Notes on the Geology and Mineral Resources of Sikkim (with a map). Chemical and Physical notes on rocks from the Salt-range, Punjab (with two plates).

Vol. XXV, 1892.

Part 1.—Annual report for 1891. Report *on the* Geology *of* Thal Chotiáli *and part of the* Mari country (with a map and 5 plates). Petrological Notes *on the* Boulder-bed *of the* Salt-range, Punjáb, Sub-recent *and* Recent Deposits *of the valley plains of* Quetta, Pishin, and the Dasht-i-Bedaolat; *with appendices on the* Chamans *of* Quetta; *and the* Artesian water-supply *of* Quetta *and* Pishin (with one plate).

Part 2.—Geology *of the* Saféd Kóh (with 2 plates of sections). Report *on a* Survey *of the* Jherria Coal-field (with a map and 3 section plates) (*out of print*).

Part 3.—*Note on the* Locality *of* Indian Tscheffkinite. Geological Sketch *of the* country north of Bhamo. Preliminary Report *on the* economic resources *of the* Amber *and* Jade mines area *in* Upper Burma. Preliminary Report *on the* Iron-Ores *and* Iron-Industries *of the* Salem District. *On the* Occurrence *of* Riebeckite *in* India. Coal *on the* Great Tenasserim River, Mergui District, Lower Burma.

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Vol. XXVI, 1893.

Part 1.—Annual report for 1892. Notes *on the* Central Himálayas (with map and plate). Note *on the occurrence of* Jadeite *in* Upper Burma (with a map). On *the* occurrence *of* Burmite, *a new* Fossil Resin *from* Upper Burma. Report *on the* Prospecting Operations, Mergui District, 1891-92.

Part 2.—Notes *on the* earthquake *in* Baluchistán *on the* 20th December 1892 (with 2 plates). Further Note *on* Burmite, *a new amber-like fossil resin from* Upper Burma. Note *on the* Alluvial deposits *and* Subterranean water-supply *of* Rangoon (with a map).

Part 3.—On the Geology *of the* Sherani Hills (with maps and plates). On Carboniferous Fossils *from* Tenasserim (with 1 plate). *On* a deep Boring *at* Chandernagore. Note *on* Granite *in the districts of* Tavoy *and* Mergui (with a plate).

Part 4.—*On the* Geology *of the country between the* Chappar Rift *and* Harnai *in* Baluchistán (with map and 3 plates). Notes *on the* Geology *of a part of the* Tenasserim Valley *with special reference to the* Tendau-Kamapying Coal-field (with two maps). *On a* Magnetite *from the* Madras Presidency containing Manganese *and* Alumina. *On* Hislopite (Haughton) (with a plate).

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1907. [May.

NOTES ON SOME INDIAN AEROLITES. BY L. L. FERMOR, A.R.S.M., B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 4 to 15.)

CONTENTS.

I.—GENERAL REMARKS.

THE object of this paper is to put on record an account of the circumstances of the fall and external characteristics of specimens of four Indian aerolites or stony meteorites, concerning which only preliminary notices have appeared.[1] No attempt has been made to investigate the mineralogical and chemical composition of these aerolites. Two of these, Karkh and Bholgháti, fell in the year 1905, whilst the other two, Haraiya and Delhi, fell in the years 1878 and 1897 respectively, but have only recently been acquired by the Geological Survey of India.

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 72, 73, (1906); *Journ. and Proceedings, Asiatic Soc. Beng., II*, pp. *xlix, l*, (June 1906).

An account is also given of the fall which took place at Andhára in 1880, although this meteorite is lost to science, as it has been made an object of worship by the inhabitants of the part of Bengal in which it fell.

It will be convenient to give in this place a list, as far as possible in chronological order, of all the falls known to have taken place within the bounds of the Indian Empire. It is possible, of course, that by a search of old astronomical and historical works records of other falls might be obtained. The list is as follows:—

List of Indian Meteoric Falls.

Year of fall.	Name of fall.	Year of fall.	Name of fall.
1798	Benares.	1857	Parnallee.
1808	Moradábád.	1860	Khairagarh.
1814	Gurram Konda.	1860	Kusiali.
1814	Chail.	1860	Dharmsála.
1815	Durala.	1861	Batsura.
1822	Kadonah.	1860-62	Meerut.
1822	Fatehpur.	1863	Pulsora.
1822 or '23	Ambála (Umballa).	1863	Shaital.
1827	Mhow (Mau).	1863	Mánbázár pargana.
1834	Chaharwala.	1865	Supuhi.
1838	Akbarpur.	1865	Gopálpur.
1838	Chandakapur.	1865	Sherghotty.
1843	Mánegáon.	1865	Maddur táluk.
1850	Shalka (Sáluká).	1865	Udipi.
1852	Yatur.	1866	Pokhra.
1852	Basti.	1866	Jamkhair.
1853	Segauli (Segowlie).	1867	Khetri.

List of Indian Meteoric Falls—contd.

Year of fall.	Name of fall.	Year of fall.	Name of fall.
1868	Lodhrán.	1886	Nammianthal.
1868	Moti-ka-nagla.	1887	Lalitpur.
1870	Nedagolla.	1890	Kakangarai.
1872	Dyalpur.	1890	Nawapali.
1873	Jhang.	1893	Bherai.
1873	Khairpur (and Maili).	1894	Bori.
1875	Sitatháli.	1895	Bishanpur (and Parjabat-pur).
1875	Nagaria.	1895	Ambapur Nagla.
1875	Queng-gouk.	1897	Gambat.
1876	Judesgherry (Judesegeri).	1897	Delhi.
1877	Bhágur (Dhulia).	1897	Kángra Valley.[1]
1878	Haraiya.	1898 (found)	Kodaikánal.
1878	Dandapur.	1899	Donga Khurd (Kohrod).
1879	Kalambi.	1901	Sindhri.
1880	Andhára.	1903	Dokáchi.
1882	Pirganj.	1905	Karkh.
1884	Pirthalla.	1905	Bholgháti.
1885	Chandpur.	Unknown	Goalpára.
1885	Sabet Mahet.		

The total number of falls recorded in this list is 71, of which all but three (Nedagolla and Kodaikánal) are stony meteorites or aerolites. Of these, 66 took place during the nineteenth century, or an average of 2 every three years. During the second half of the century,

[1]This is a meteorite recently described by Professor W. N. Hartley in *Proc. Chem. Soc., London*, Vol. 22, p. 251.

in which, in all probability, a larger proportion than previously of the falls which occurred were brought to the notice of science, 52 falls were recorded in 50 years or roughly 1 every year. Hence it can be expected that on the average at least one meteoric fall a year within the limits of the Indian Empire will be recorded during the twentieth century. The actual number of falls is probably considerably larger than the recorded number; for if the falls be arranged according to provinces, thus:—

United Provinces	21
Panjáb	10
Bengal	8
Madras	8
Bombay	7
Central Provinces	5
Eastern Bengal and Assam	4
Rájputána	3
Central India	2
Mysore	2
Baluchistán	1
Burma	1
	72[1]

it becomes evident that meteoric falls are most frequently reported in areas where the population is densest. Meteorites probably fall just as often in the less densely populated areas, where, however, they have less chance of being observed. Similar considerations, no doubt, explain why India, being, on the average, a very densely populated country, is apparently one of the most favoured parts of the earth's surface for meteoric falls. They do not explain, however, why the 71 falls recorded for India consist of 68 aerolites, 2 siderites or irons (Nedagolla and Kodaikánal), and 1 siderolite (Lodhrán), while out of 24[2] supposed meteorites recorded from Australia, 19 are siderites or irons, 2 are siderolites, and only 3 are aerolites or stones.

Specimens of all the falls given in the list on pages 80 and 81 are in the Museum of the Geological Survey of India, with the exception of Gurram Konda, Chail, Bherai, and Kangra Valley, portions of all of which we should like to acquire by exchange, and of Andhára of which no portion has reached any museum.

[1] One fall, Khairpur and Mailsi, took place in both the Panjáb and Rájputána.
[2] According to the 1904 "Catalogue of the Ward-Coonlay Collection of Meteorites," by the late H. A. Ward.

II.—THE BHOLGHÁTI METEORITE (No. 241).[1]

This meteorite fell at about 8-30 A.M., on 29th October, 1905, at Bholgháti village (22° 5′ N. and 86° 54′ E.), Deoli pargana, Morbhanj State, Bengal. According to a statement of Karu Majhi, son of Anupa Majhi, of Bholgháti, forwarded under cover of a letter from His Highness the Maharaja of Morbhanj,

"The sky was not cloudy. The meteorites fell almost simultaneously. His attention was first attracted by the noise resembling the roaring (dho—dho—) of the clouds. He looked up and saw two stones approaching the earth. They were not luminous. When they approached further the noise resembled that of rocket (sar-r-r). One of the meteorites fell a few paces off his verandah where he was sitting at the time of the occurrence, and the other in the jungle about 150 yards off his house. He took away the first one as soon as it fell down."

This is the meteoric stone (241·A) which was forwarded and presented to the Geological Survey of India by Mr. P. N. Bose, Geologist to the Morbhanj State, on behalf of the Maharaja. The second piece (241·B), which fell in the jungle close by, was also recovered and is the property of the Morbhanj Museum, but has been lent to the Geological Survey for examination.

These two pieces weighed respectively 1,000·6 and 1,578·9 grammes, giving a total of 2,579·5 grammes for the fall.

The first meteorite (241·A) received weighs 1,000·6 grammes, and is almost a complete aerolite, except for a few pieces chipped off. Its general appearance and shape are well shown in Plates 4 to 6.[2] If the portions chipped off were restored to the stone its shape would be roughly that of a tetrahedron, of which one side forms the base on which the meteorite rests in Plates 4 and 5. The other three sides of the tetrahedron may be designated A, B, and C, as indicated on the plates. In Plate 6, the meteorite is inverted so as to show this base uppermost. The crust is brownish-black, in some places dull, but in others shining black. The shiny parts form little glossy specks and patches, the latter being in places quite large, as is well

[1] The number of the meteorite in the register of the Geological Survey collection.

[2] I must express my thanks to Mr. H. B. W. Garrick for the fine set of photographs with which I am able to illustrate this paper.

seen in Plate 4, fig. 1. There are a few shallow pittings shown in Plate 4, fig. 1.

Where fractured the aerolite shows a dark-grey matrix in which are set many white greenish and brownish, angular and rounded, patches, shown well in Plate 4, fig. 2, which is somewhat enlarged, the photographic plate having been exposed for the contrast in the fractured part of the meteorite instead of for the detail in the crust, as was the case in fig. 1.

Some of these patches are $\frac{1}{4}$ or even $\frac{3}{8}$ inch long, and while some of them are seen to be composed entirely of one mineral, others resemble rather fine-grained rock fragments, and together they cause the meteorite to resemble a volcanic rock containing phenocrysts and angular fragments of rock in a dark fine-grained matrix. There are also some included black patches up to $\frac{1}{4}$ inch in diameter, one of which is shown in Plate 5 in the fractured part. A small chip of this heated on platinum became pale greyish in colour, so that it is probably partly composed of carbonaceous matter.

The second aerolite (241·B) weighs 1,578·9 grammes and is figured in Plates 7 and 8. The stone is roughly rectangular in shape and is covered with crust on five sides. The remaining one, the top side as seen in Plate 7, is made up of fracture-surfaces, of which the left hand portion is quite free from crust; whilst the right hand portion is a fracture which must have formed by the splitting off of a piece of the aerolite whilst still in air, for the fracture has since been partly covered with a new crust. This new crust is well shown in Plate 8, on the fracture-surface seen to the left. The front face of the meteorite (Plate 7) is beautifully curved and is covered with a dull blackish crust, on top of which are patches and networks, especially towards the edges, of a shining dark brown slag-like vitreous crust. The right hand end seen in Plate 8 shows parallel fluidal ridges of shiny brownish-black crust with some of the same smooth angular black patches of shiny crust as are seen in the other aerolite. In only one place on either stone does one of these smooth black patches of crust come against the edge of a fracture, and here it is seen to correspond to one of the whitish angular rock-like fragments which are included in the dark grey ground-mass; the probability therefore is that all these shiny smooth parts of the crust correspond to underlying breccia-like or porphyritic inclusions in the dark-grey ground-mass. This indicates that at least some of the light angular patches are more easily fused than the main part of the aerolite. The back side of the aerolite is similar to the right hand end, whilst the left hand end and base of the stone are formed by fracture-surfaces, formed long before the stone reached the earth, as they have been almost completely recovered by crust.

III.—THE KARKH METEORITE (No. 239).

The first indication that a meteoric fall had taken place in the Jhálawán Agency, Baluchistán, was an extract from the diary of Major H. L. Showers, Political Agent, Kalat, forwarded to the Geological Survey Office by the First Assistant to the Agent to the Governor-General and Chief Commissioner in Baluchistán. This extract contained an extract from the diary of the Native Assistant, Jhálawán, relating to phenomena noticed on the 27th April, 1905. The Native Assistant was passing near the Nar spring in the Mula Pass about 1 P.M. when he heard what he thought was the report of a gun on the adjacent hills. This was followed by another "echo" of the same sort, soon followed by a "thundering noise." The sky was cloudless. This noise resembling thunder is reported to have been heard all round the Mula Pass up to Naulang and several people are said to have seen "a flaming star like a ball running about during the middle of the day. Before the thundering noise ended the ball became extinguished and left clouds of smoke after it. The flaming ball is said to have had a long tail of smoke."

The Native Assistant's diary further states:—

"It is reported from Karkh that the noise rose in the Wehari Hills near Karkh and a star was seen rising from the top of a hill and some big stones were heard falling from the hill."

It seemed probable that this last passage indicated the fall of a large meteorite near Karkh, and this probability was confirmed when, in response to a request from the Director of the Geological Survey that a search should be made, the fine mass of meteoric stone shown in Plates 9 to 11 was received from Karkh, having been obtained by Major Showers.

Mr. Vredenburg of the Geological Survey of India subsequently visited Karkh and obtained from the Native Assistant, Jhálawán, a second piece of the meteorite, shown in Plate 12. He was unable, however, to obtain any trustworthy details as to the exact circumstances of the find, or to trace what had become of the remainder of the meteorite, for the two masses obtained were evidently only portions of a very large meteorite.

Subsequently, however, as the result of further enquiries, Major Showers gained some additional information, according to which the meteorites fell at two different places, 15 miles apart, on the same date. The large piece (239·A), and probably also the second piece (239·B) mentioned above, was found on the banks of a dry nullah below the Sumbáji Hills. Many small fragments (239·C and 239·D) were collected at this locality where they "were found in a small oval-shaped hollow about two feet in diameter and one foot deep." "The second meteorite fell in the Michára hills on a flat piece of sheet rock. In falling it fractured the rock and was itself broken into four pieces." Two of these, 239·E and 239·F, have reached the Geological Survey collection through the Second Assistant to the Agent to the Governor-General in Baluchistán, and Mr. G. H. Tipper.

The Sumbáji Hills (highest point △ 6,448 feet) lie about 14 miles W. N. W. of Karkh and the Michára Hills about 5 miles W. N. W. of this place, so that the distance between the two spots is about 9 miles. The line joining these two sets of hills lies about W. N. W. to N. W. and this line should correspond with that of the flight of the meteorite. If the fact[1] that a much larger total weight (18,896 grammes) of meteorite was received from the Sumbáji Hills than from the Michára Hills (2,939 grammes) can be taken to indicate that a larger weight fell in the former place, then it seems probable that the direction of flight was from S. E. to N. W. or from E. S. E. to W. N. W. For we can suppose that the original meteoritic mass fractured at a considerable height above the earth's surface into two main pieces, of which the heavier travelled farther than the lighter. The piece which fell in the Sumbáji Hills may not have suffered further disruption till impact with the earth's surface or until broken by human agency. But the Michára portion must have disrupted before impact with the earth's surface, for the two pieces received from these hills had evidently become separate before they reached the earth's surface, as the fracture-surfaces of one piece are covered with a thin crust.

[1] On page 89 it is noticed that there has evidently been some mistake made with regard to the place of origin of C, D, E, and F. But even if we suppose C and D, as well as E and F, to have come from the Michára Hills, it still gives a much larger total weight from the Sumbáji Hills

The weights of the various pieces of this fall as received in the Geological Survey Office are shown in the following table:—

Place of Origin.	Number.	Weight.	Total weight for each locality.	Total weight of fall received.
		Grammes.	Grammes.	Grammes.
The Sumbáji Hills	239·A	14,546		
	239·B	3,087		
	239·C	878		
	239·D	385	18,896	
The Michára Hills	239·E	2,196		
	239·F	743	2,939	21,735

21,735 grammes is about 47·7 lbs.

The largest mass (239·A) is evidently but a portion of a much larger mass, but the fractured surfaces do not look very fresh so that the meteorite may have broken at the time of hitting the hill. It is covered by crust over about one-half its superficies. This crust is nearly all dull black, but at one end has adherent to it a number of rather soft white patches which effervesce with dilute acid and probably indicate that the meteorite fell on a limestone formation.

Plates 9 and 11 show the shape of this mass. There are abundant pittings or thumb-marks on the crust; these are seen in Plate 9, which is only half natural size. In Plate 10 a portion of the crust is shown natural size. This shows the groove-like character of some of these pittings. It is evident from the beautiful flow-structures shown by the crust on one side of these grooves that they must have been scooped out of the fused exterior of the aerolite by the air as it rushed over the surface of the meteorite during its rapid flight through the earth's atmosphere.

This flow-structure indicates the orientation of the meteorite in the line of flight during the time in which these grooves were cut out, the molten crust flowing, of course, towards the rear end of the stone. One portion of the crust shows a little slickensiding striation.

The fractured surfaces are of a dark ash-grey colour and where freshest show a few very light-grey chondri usually about $\frac{1}{16}$ inch in diameter. There are also scattered pale yellowish metallic points.

The smaller piece (239·B), though evidently a part of the same fall, does not fit the larger piece anywhere. One side of it, shown in Plate 12, fig. 1, is completely covered with a rather dull black crust, showing groove-like pittings and flow-structures where the molten crust has flowed over the top edge of the side shown. There is also a certain proportion of crust on the top side of the meteorite. This is shown in fig. 2 in which we are looking down on the fragment placed as in fig. 1. The crust on this surface has in places a scoriaceous or cindery appearance. Besides this fig. 2 also shows, in the S. E. corner, the thickness of the crust which is somewhat variable but seems to average about 0·5 mm. The back surface of the fragment as placed in fig. 1 consists entirely of fracture-surfaces, while the base on which it rests is largely covered with a thin dull (in places rather shiny) black coating and is possibly a fracture, produced by the disruption of the meteorite during flight, over which a very thin coating of crust formed before the stone reached the ground. On account of this old fracture-surface it seems probable that this piece and the large mass are portions of two separate sections of the meteorite which were disrupted from one another during flight and reached the ground separately.

239·C and 239·D were received together and consist of a weight of 1,264 grammes of chips. These were separated into 122 larger pieces weighing 878 grammes, of which the largest weighed 25·7 grammes, and some 200 to 300 smaller chips. Many of the chips are bounded entirely by fracture-surfaces, but a certain proportion have a little crust on one side. The fractures are evidently old, being now somewhat rusty, and many of them have on them a little soft buff-grey calcareous matter which is probably of the nature of tufa deposited on them as they lay on the ground. From this it must be concluded either that they were broken off at the time of impact of the meteor with the ground, or, and more probably, that they were broken off by the natives in their curiosity to see what the stone was. In either case they must have been left lying on the ground for a sufficient length of time for surface waters to have deposited on them calcareous tufa derived either from immediately underlying or from neighbouring limestone. Most of the fragments were of the same character as 239·A, but there were a few chips of a fine-grained pale grey rock, one piece having a layer of nickel-iron attached. Of 14 of these pieces, 12 had crust attached, and the remaining 2 had a secondary crust. In fact, it is evident that these chips are a portion of a similar layer of stone forming part of 239·E, and consequently that the information about the localities, according to which C and D fell on the Sumbáji Hills and E and F on the Michára Hills, is open to some doubt. If meteoritic matter did fall at these two separate places, then the specimens from these two localities must have been mixed before they reached Major Showers.

239·E is not figured here. It is about 6½ inches long by 4½ inches broad and 4 inches high, and is perhaps ⅛ covered with a dull black smooth crust (which may be called primary crust), whilst there are five fracture planes on which the rock has been re-fused so as to form a thin black, slightly shiny crust. The fresh fracture is of the usual dark grey. The most interesting point about this stone is that at one end there is a layer of much finer grained and much paler (light brownish grey) meteoritic material than forms the main mass of this stone and the whole of all the others except 239·F. This layer is ⅝ inch thick, 2½ inches long, and 2 inches broad. It is so fine-grained and structureless in appearance that it looks like a very fine-grained limestone at first sight. It is joined to the remainder of the meteorite along a flat surface which has been partly uncovered, owing to the chipping off of pieces of the lighter rock, so as to show signs of a shiny black crust-like layer separating the two portions of the stone. There is also a slight difference in the texture of the crust covering the two portions of the stone. In the fine-grained portion there are areas of yellowish nickel-iron in thin layers up to half an inch across.

239·F, which is also not figured, is about 3¾ inches long, 3 inches broad, and 2½ inches deep. Over one-half of it is covered with a black crust, rather shiny in places. On the fracture-surfaces are abundant tiny yellow specks of nickel-iron striking up. At one end is a little of the fine-grained light grey material similar to that in 239·E, but the junction between the light and the dark portions is obscured.

Composition of the meteorite.

Dilute hydrochloric acid applied to a fresh fracture-surface of any of the pieces of this fall gives rise to the emission of a strong smell of sulphuretted hydrogen. Microscope sections indicate that the stone is a rock composed mainly of olivine, enstatite, nickel-iron, an opaque constituent suggesting pyrrhotite by its bronzy lustre, and an opaque black mineral. Both the latter are probably sulphides. The specific gravity of the large pieces 239·A was roughly determined as 3·60. That of 239·F is 3·55.

IV.—THE DELHI METEORITE (No. 238).

According to a letter, dated 19th February, 1898, from Mr. J. Greson, Inspector of Railway Police, Allahabad, to the Reverend Father Francotte, S.J., of St. Xavier's College, Calcutta, some natives who were working in the fields in the evening of the 18th October, 1897, saw at about 7-30 P.M. a meteor of unusual brilliancy; a few seconds after, a noise similar to thunder was heard, and about the same time two stone-like bodies (each weighing about a pound) were heard to fall. They were black on the outside, but when broken were light blue or greyish.

Unfortunately this occurrence was not brought to our notice till 1903, and it was then impossible to trace these stones, partly on account of a change of the district officials, but no doubt partly due to the reluctance of the owners of the pieces, into which the stones had broken, to admit their possession. Hence the only specimen of this fall in the Geological Survey Museum is a tiny fragment sent with the above-cited letter by Mr. Greson to Father Francotte, who kindly presented it to our collection. It weighs only 0·79 gramme and has a little crust on one side. The fractured surfaces are light grey and show abundant tiny specks, probably of nickel-iron in a whitish matrix through which are scattered brownish and greyish granules. The place of the fall was a village some 5 miles from Delhi near the famous Kutb Minár.

V.—THE HARAIYA METEORITE (No. 237).

This meteorite was recently obtained from Mr. R. B. Reid of Allahabad, and the following is an abstract of the particulars furnished by him:—

It fell in the Basti district (United Provinces), about 14 miles west of the Sadr station in the afternoon during August or September, 1878, and was secured by Mr. Reid, who, on account of an exceptionally violent crash of thunder and brilliant flash of lightning, which he saw from his verandah during a thunderstorm, sent out a messenger who returned three days later with the meteorite. It appears that three people were weeding a field about a mile out of the village close to a mahua tree. It was raining hard at the time, and according to one of the survivors "suddenly a crashing peal of thunder resounded, he heard a whirring sound above him, like unto a kite descending then, as if a body came down with a thud on the ground." He and the second man were rendered insensible, and on coming to he saw that an old woman, one of the three weeders, was charred and dead. Close by her was a large mark on the ground, where the earth had been splattered up, giving the appearance as if something had entered the ground. The spot was dug up and at a depth of about 5 feet from the surface the meteorite was found buried.

The above account is given for what it is worth. The chief point is that Mr. Reid no longer remembers the name of the village, nor did he record the exact date of the fall, although he is sure of the year. As the large village of Haraiya (latitude 26° 48′ N.—longitude 82° 31½′ E.) is situated in the position indicated (14 miles west of the town of Basti) this name has been attached to the fall. It is just possible that this aerolite is only another portion of the Dandapur fall of 5th September, 1878. This, however, is not very probable (1) because Haraiya and Dandapur (26° 55′—83° 58′) are 88 miles apart, (2) because the Haraiya fall is said to have taken place in a thunderstorm while the sky at Dandapur was comparatively cloudless.

The specimen is a nearly perfect aerolite weighing 1,078·8 grammes. It is almost completely covered with a shiny black crust which has got knocked or peeled off in a few places as can be seen from the photographs of this meteorite (Plates 13 to 15). Plates 13 and 14 show the front side of this meteorite, and it will be seen that the crust exhibits a beautiful series of delicate ridges radiating from about the centre of this side of the stone. They indicate, of course, that this was the front side of the stone when in flight, and were caused by the rapid passage of the air over the molten crust. The symmetry of these radiations is spoilt by the prominent pittings or thumb-marks occupying part of this side. That these finger-like depressions were formed before the radiating flow-lines of the crust is shown by the fact that these lines continue through the pittings and out again on the other side.[1] The other side of the meteorite is shown in

[1] The remarkable likeness of these pittings or depressions to finger-marks is illustrated by the following passage from Mr. Reid's letter giving the details of the fall:—"The meteorite was found buried, apparently not quite hardened, as it has admitted of the finger prints and palm of the hand being impressed on it, when pulled up by the digger."

Plate 15, and although the crust has cracked off over a considerable part of this surface, yet the delicate radiating flow-lines (finer and closer together than on the front side) are well seen. They indicate the flow of the molten crust from the edge towards the centre of this side.

The fracture of this meteorite differs from that of the two preceding in its almost white colour. It shows numerous little dark specks in a white matrix.

VI.—THE ANDHÁRA METEORITE.

On the 2nd December, 1880, a meteoric fall took place at Andhára in the Muzaffarpur district, Bengal, which seems to have escaped notice on the part of students of meteorites. An account of it was given at the time by Major-General A. Cunningham in the Archæological Survey of India Reports, Vol. XVI, pages 32-34 (1883), and as this publication is not generally accessible in geological libraries, I have thought it desirable to reproduce here Cunningham's account of this fall. Some notes on this fall were also given by Mr. H. B. W. Garrick, who brought this fall to my notice, on pages 98 and 99 of the above-cited volume; but as they do not contain anything not in Cunningham's report, they are not repeated here.

"Andhára or Ujyân is a small village on the bank of the Parewâ, or Parwâ Nala, on the bed of the Bâgmati, 4 miles to the west of Sitâmarhi, and 30 miles to the north of Muzaffarpur. Here, on the *amávasi* of Agrahan (the conjunction or new moon of Agrahayan—2nd December, 1880) at 4 o'clock in the afternoon, a sound like that of a gun was heard, and two Brahmans of the village saw a dark ball fall in a field to the south-west of the village. It is described as having come down almost perpendicularly, but the sound was heard in the west, and a small cloud of dust rose up where it struck the ground. On picking it up it was quite warm and appeared to be white, but it was only covered with dust, and on washing it, its colour became quite black. I heard of its fall a few days afterwards when on my way to Muzaffarpur, and I visited the place on the 30th December.

"My chief object in going to Andhára was to witness the rise of a new worship, which may serve to throw light on the history of several of the *lingams* of Siva, which are very probably only stones that fell from heaven, like the Diana at Ephesus. 'What man is there that knoweth not how that the city of the Ephesians is a worshipper of the great goddess Diana, and of the image which fell down from Jupiter.'[1]

"Immediately after its fall the meteorite of Andhára became an object of worship. Two Brahmans at once established themselves as its ministering priests, one of them of course belonging to the village, but the other was a wandering Brahman or *Jogi* from Benares. I heard that it had been visited daily by crowds of people, latterly by as many as 500 a day. At the time of my arrival, about 8 o'clock in the morning, there was a continuous stream of people from all quarters. During the forenoon the stream became less continuous, and about midday was intermittent. I saw parties of 5, 10, 15, and 20 still coming from all sides. I counted one party of 23 people. During the early morning there could not have been less than 300 people present between 8 and 10 o'clock, and nearly as many more came before 2 o'clock. I counted roughly 400 persons up to 11 o'clock. On Sundays, they are said to be many more, certainly more than 1,000, and probably not less than 2,000. On the following Sunday, when I was encamped at Kura, 2 miles to the south-west of Parsoni, and 7 miles to the south-south-west of Andhára, the people were flocking to see the meteorite in a continuous stream. I estimated that not less than 4,000 people must have passed my tent; and as there were three other roads as much frequented as the other three sides, there could not have been less than 10,000 visitors on that Sunday.

"The people at Andhára asserted that the offerings made at the shrine amounted to as much as Rs. 20 a day, and that Rs. 400 had been collected up to the time of my visit, that is, in 28 days. The Jogi, however, denied this, and admitted only Rs. 4 or Rs. 5 a day. But as almost everybody gives something, however small, say from one *paisa* to two annas (a two-anna piece was seen by my servants on the 27th) 600 *paisa* or 150 annas, or nearly Rs. 10, would be a minimum daily collection.

"A brick temple had already been begun, and at the time of my visit the walls were about 2 feet high. The votaries crowded in to make their offerings of flowers, sweetmeats, milk, rice, water, bel-leaves, besides money, both silver and copper. Two bel-trees close by had already been stripped of their leaves. After making their offerings the people knelt down in front and with joined hands

[1] Acts of the Apostles, XIX, 35.

muttered some prayers. One old woman, who seemed to be particularly earnest, even clasped the stone.

"When the crowds of votaries had somewhat lessened, I got a good view of the stone. It was about the same size and shape as a common loaf of Indian bread, flattish below, and rounded above, and 4½ inches in height; its colour was apparently quite black. On one side there was a deep indentation as if a piece had been broken off. During the course of the day I heard that the missing piece had been found the day before in a field near the village of Rusâri, half a mile to the west of Andhára. When brought, the two stones were found to fit exactly. After 3 o'clock, when the crowds of votaries had gone off to their homes, I examined the stone quite close. It was quite black, flattish below and rounded above. I did not touch it, but it was measured before me by one of the attendant Brahmans. Its shape was oval, 6½ inches by 4½ in length and breadth, and 4½ inches high. Its weight was said to be about 3 seers, or 6 pounds. The circumference was 16¾ inches. By this measurement the diameter is 5·366 inches, and by that of the two diameters the mean is 5·37 inches.

"This new ***avatar*** of Mahâdeva has received the name ***Adbhuta-Náth***, 'the miraculous or wonderful god,' and its fame has spread all over the districts of Tirhût and Champâran."

In response to an enquiry on the subject the Officiating Collector of Muzaffarpur has recently replied that there is no possibility of procuring for the museum any portion of this meteorite, as a temple has been built over the place where the stone fell and a *mela* and fair have been started in connection with the worship of the stone by which means the temple receives a considerable annual income.

VII.—THE KALAMBI, BHÁGUR, JAMKHAIR, AND PIRGANJ METEORITES.

These four Indian aerolites have long been known to science, but until this year (1906) they have not been represented in the Geological Survey collection. We are indebted, for their addition, to the generosity of the Trustees of the British Museum and of the Director of the K. K. Naturhistorisches Hofmuseum, Vienna.

The Kalambi meteorite (No. 243).

Of this meteorite, which fell on the 4th November, 1879, at the village of Kalambi, Wai taluq, Sátára district, two small pieces weighing respectively 6·40 and 4·58 grammes were received during the present year from the Hofmuseum, Vienna. Judging from "Die Meteoriten in Sammlungen" by Dr. E. A. Wülfing, p. 177, (1897), the original notice of this meteorite has escaped inclusion in the literature of this subject. It is to be found on page *lvi* of the Abstract of the Proceedings of the Bombay Branch of the Royal Asiatic Society which is appended to Vol. XIV of the Journal of that Society, 1880. The village at which the stone fell is probably that marked as Kalambha (17° 49½′—73° 59′) on Standard Sheet No. 201, Bombay Survey. The main mass of the stone seems to be still in the possession of the above Society.

The Bhágur (Dhulia) meteorite (No. 244).

A small fragment, weighing 2·5 grammes, of the meteorite which fell on November 27th, 1877, at Bhágur near Dhulia in the Khandesh district, Bombay Presidency, has recently been presented by the Trustees of the British Museum, to the Geological Survey Museum. The original account of this fall is given in *Jour. Bomb. Branch Roy. Asiatic Soc., XIV*, Abstract of the Society's Proceedings, pp. *iii-vi*, (1878). The main mass, the weight of which is unknown, seems to be buried in the collection of this Society.

The Jamkhair meteorite (No. 245).

A small fragment, weighing 1·7 grammes, of the meteorite which fell on the 5th October, 1866, at Jamkhair, Ahmadnagar district, Bombay Presidency, was also received in 1906 from the British Museum.

The Pirganj meteorite (No. 246).

Of this meteorite which fell on the 29th August, 1882, at Pirganj, Dinajpur district, Eastern Bengal and Assam, (formerly Bengal), a small piece weighing 16·2 grammes has also been received from the British Museum.

LIST OF PLATES.

Note—The titles of plates 14 and 15 have unfortunately been interchanged.

NOTE ON THE BRINE-WELL AT BAWGYO, NORTHERN SHAN STATES. BY T. D. LA TOUCHE, B.A., F.G.S., *Superintendent, Geological Survey of India.* (With Plate 16.)

THE brine-well at Bawgyo, a large village on the bank of the Myitnge or Nam Tu river, six miles east-south-east of Hsipaw, the capital of the state of that name, is situated in latitude 22° 35′, longitude 97° 16′ 15″, about half a mile slightly east of north from the railway station of Bawgyo. It lies at the northern edge of the valley, which is here broad and level, at the foot of a precipitous scarp of limestone, marking the line of a fault with up-throw to the north.

The well was visited on the 8th of June, 1890, by Dr. Noetling, Palæontologist, Geological Survey of India, who published a short paper on the subject in the *Records*, Vol. XXIV, Pt. 2. The date of my visit was almost exactly six months later in the year 1905, on the 19th December, and as Dr. Noetling says that he was assured by the natives that the output of salt varies with the seasons, it is now possible to arrive at an estimate of the average production with some degree of accuracy. It will be seen from what follows that my estimate of the production is very largely in excess of that of Dr. Noetling, who put it at only 12½ viss, or 45½ lb., a day in the rainy season, and 20 viss, or 73 lb., in the dry season. The present enquiry was undertaken mainly for the purpose of ascertaining the amount of sulphate of soda that is available from this source, since a possible demand for this substance may arise in connection with the proposal to establish a wood-pulp industry in Burma, with which end in view experiments are now being made to test the suitability of the various timbers grown in the province. The analysis of a sample of the brine collected by Dr. Noetling had already shown that sulphate of soda forms a large proportion of the solid matter contained in it.

There is only one well at present in use, but, as Dr. Noetling remarks, the villagers say that there was formerly a second well, the site of which was pointed out to me as about 50 yards to the north-east of the existing well. No trace of this second well now remains. The reason given to Dr. Noetling for its abandonment was that it yielded so large a quantity of brine that the villagers were unable to work it, but I was informed that it was on account of the red colour of the salt, which rendered it unsaleable.

The existing well is square in section, measuring 4 feet by 3 feet 8 inches, and is about 45 feet deep. At the time of my visit, in December, the level of the brine stood at about 7 feet below the surface of the ground. The brine is baled out with an ordinary bucket at the end of a balanced pole, enough being taken out at a time, and stored in troughs made of hollowed-out logs, to keep the boiling pans at work, with intervals for rest, etc., till the well fills again, an amount that has been found by experience. When I saw it, the surface of the brine was lowered about 11 feet after 9 hours' baling, and this, I was told, was the usual quantity taken out at a time. This would be about 1,000 gallons.

At intervals during the baling, several buckets-full of the brine are poured back into the well with as much force as possible, in order to mix up that which remains below. This process would counteract to a certain extent the effect of dilution during the rains, which, in Dr. Noetling's opinion, causes the weaker brine to float to the surface; but that there is a decided difference between the strength of the brine in the rainy and dry seasons appears to be evident from the amount of solid contents in Dr. Noetling's sample and in the one collected by me. These are—

	Sample collected, 8th June, 1890. Per cent.	Sample collected, 19th December, 1905. Per cent.
Water	87·47	74·42
Total salts	12·53	25·58
	100·00	100·00

It is possible that Dr. Noetling's sample was taken when the brine had been undisturbed for some time, when the surface layers would naturally be comparatively weak. Since, however, the well stands in what is practically a swamp, and is not particularly well protected at the top, there must be a considerable influx of surface water into it during heavy rains.

The boiling is carried on in a shed situated near the well. The brine is placed in shallow iron pans, each holding about 6 gallons, which are set in pairs in a furnace built of clay, of the shape shown in the figures attached. I found that it took just two hours for the contents of each pan to evaporate to the extent required. This is not to dryness, but to a point at which the residue is of the consistency of wet mortar, and a crust begins to form on the surface. The wet mass is then scraped out into a cloth, and allowed to drain and cool, after which it is packed in baskets containing 200 viss (=6½ cwt.) each, and well rammed into a solid mass with wooden mallets.

During the operation of boiling, the pan is well scraped from time to time with an iron-shod stick to loosen the scale, consisting largely of sulphate of soda, which is continually forming on the bottom. This is done probably to avoid loss of heat. A few chips of resinous pine wood are also placed in the pan, and are said to prevent the formation of scale to a certain extent. But shortly before the boiling is finished the scraping is stopped, and the scale allowed to collect. This is removed as soon as the fresh brine, which is added the instant that the salt has been taken out, has become warm, and so loosened it. This is the only attempt made to refine the salt. The scale is stored separately, and is sold for feeding cattle.

The salt obtained from each pan of brine, 6 gallons at a time (*i.e.*, in two hours), weighed 4½ viss, or 16·42 lb. But as Dr. Noetling says that during the rainy season not more than 2½ viss is obtained, and as the quantity of salt shown in the analysis of the sample collected by him bears out this statement, I think that 3 viss per pan may be taken as a fair average throughout the year, as a basis for calculation. This is almost exactly 11 lb. With 12 pans at work, as there were at the time of my visit, the average output would therefore be $\frac{12 \times 11}{2}$ = 66 lb. per hour, or 14 cwt. a day. The workmen told me that they turn out an average of 400 viss, or 13 cwt. a day, but this is probably the maximum, obtained when they are getting 4½ viss at a time from each pan. This would mean about 15 hours' work a day and would allow sufficient interval for rest and food.

The well is being worked to quite its full capacity, for I found that the level of the brine rises at the rate of 3 inches an hour, after the baling has ceased. It would therefore take 44 hours to fill up the 9 feet that is taken out at a time. This amount of brine, approximately 1,000 gallons, would produce, at the rate of 11 lb. salt to each 6 gallons, 1,833 lb. of salt, which would take 28 hours' or nearly two days' work to boil down.

The possible average annual production, if the well were worked continuously, may be calculated as follows:—The amount of brine available may be taken as $3\frac{2}{3} \times 4 \times \frac{1}{4} = 3{\cdot}66$ cubic feet, or 23 gallons per hour. This would produce, at the rate of 11 lb. of salt to each 6 gallons, $\frac{28}{6} \times 11 \times 24 = 1{,}000$ lb. approximately, or 9 cwt. per day, which amounts to an output of 164 tons per annum. To this has to be added the amount of scale produced which varies considerably in each pan of brine, and cannot be estimated accurately. It would perhaps bring the total up to 200 tons per annum.

Two analyses of the solid contents of the brine have been made, one in Rangoon from the sample collected by Dr. Noetling, and the other in the Geological Survey Laboratory. The results as given below are very closely in accordance:—

	ANALYSES MADE AT	
	Rangoon.	Calcutta.
	Per cent.	Per cent.
Sodium chloride	60·30	60·48
Sodium sulphate	34·64	36·24
Calcuim sulphate	1·00	0·21
Magnesium sulphate	0·86	0·65
Undetermined (potassium, etc.) . . .	3·30	2·42
TOTAL .	100·10	100·00

Taking the average amount of sodium sulphate, as shown by these analyses, as 35·44 per cent., and presuming that the whole of this salt could be separated from the chloride, the total amount procurable during the year would be 70 tons.

This is the total amount that could be procured from the existing well; but if there is any truth in the statement that a second well produced brine that was even more rich in salt than the one now worked, there seems to be no reason why the production should not be largely increased. In any case as the brine rises through a fault fissure, it is exceedingly probable that other wells put down along the line of the fault would yield a greater or less amount of it, and if a demand for the sulphate of soda arises, it would be well worth while to sink other wells in the neighbourhood. If the sulphate could be utilized in any way, either in the manufacture of wood pulp, or otherwise, it would be of great advantage to the salt industry of the locality, for, as the salt is sold in its crude state and commands a ready sale among the hill people as far east as the Wa country beyond the Salween, it cannot compete in price with the ordinary bazaar salt in places where this is sold, on account of its bitter taste, due to the admixture of the sulphate of soda. It is sold at Rs. 5 a hundred viss, or a little over one rupee a maund. The proceeds, after deducting cost of firewood, wages, etc., go to the Bawgyo pagoda. The Sawbwa of Hsipaw derives little or no revenue from the industry.

REPORT ON THE GOLD-BEARING DEPOSITS OF LOI TWANG, SHAN STATES, BURMA. BY T. D. LA TOUCHE, B.A., F.G.S., *Superintendent, Geological Survey of India.*

Geology of the district.

SOME 50 miles to the south-east of the town of Hsipaw, the capital of the state of that name, a lofty mass of hills, attaining an elevation of 6,672 ft. above the sea in Loi Pan, rises abruptly from the undulating plateau of Palæozoic limestone which constitutes the whole of the intervening country. The northern end of this massif is formed of ancient micaceous slaty rocks, of which the exact age is at present unknown, though there is not the least doubt that they are older than the Ordovician period. They resemble, speaking generally, the slaty and quartzitic series to the south of the Mogok gneiss in the Ruby Mines district, to which the name Chaung-Magyi series has been given. These rocks are traversed by thick intrusions of granite, to which their present altered condition may be due, and in consequence their strike is somewhat irregular, but it appears to be generally from N. W. to S. E. A small quantity of gold is found among these rocks on the eastern flank of the range and has been washed on a small scale by the natives near the village of Hwe-pen (22° 15′: 97° 48′).

Proceeding southwards from Loi Pan in the direction of the town of Möng Tung (22° 1′ 30″: 97° 44′), the hills gradually become lower, and a series of quartzose and felspathic sandstones, with thick bands of yellow shale, is met with. These rocks are as a rule very poorly exposed, and it is very difficult to find outcrops of them, even in the ravines. The hill sides are covered with a thick deposit of sandy clay, and one may walk over them for miles without seeing a single fragment of solid rock. It is impossible to say therefore where the boundary occurs between this series and the slaty rocks to the north, but I first met with the sandstones *in situ* near the village of Se-heng, between 4 and 5 miles due north of Möng Tung, and it is probable that the boundary runs somewhat further to the north. On the latitude of Möng Tung the prevailing strike of these beds is W. N. W.—E. S. E., but further south it becomes due north and south, and they form the whole of the Loi Twang range, the principal axis of which runs in the same direction. Loi-Twang itself, at the southern end of the range, rises to an elevation of 5,752 ft. Where these rocks are found *in situ* they are quite unaltered, and in some cases the surface of the beds is covered with well defined ripple marks. But neither in the sandstones nor in the shales has the slightest trace of any organism been found. Occasionally the sandstones contain small scattered cubical crystals of iron pyrites, which also occur in some very similar sandstones to the north-west of Hsipaw, where they overlie the Chaung-Magyi series. They also contain numerous veins and nests of white quartz. This sandy series may be known for the present as the Loi Twang series.

Along the eastern flank of the range is found a narrow band of highly fossiliferous shales, which is shown by its characteristic fossils, *Rafinesquina*, cystidean plates, etc., to be identical with the Naungkangyi shales (Ordovician) of the Maymyo area. These rocks have been traced for about 24 miles from N. E. to S. W., generally occupying a narrow valley between the Loi Twang series and the overlying beds. In places they appear to rest conformably on the former, but in other cases the strikes are quite discordant, and although it would be difficult, in the absence of fossils, to distinguish the Naungkangyi from the Loi Twang shale, the abundance of organic remains in the former probably indicates a considerable lapse of time between the periods of deposition of the two series.

The Naungkangyi shales are followed by a great thickness of purple and grey micaceous shales, which are also highly fossiliferous, containing fine specimens of trilobites in places, as well as detached plates of cystideans. They do not, however, contain the *Brachiopoda* characteristic of the Naungkangyis, but resemble closely a narrow band of purple shaly limestone which is commonly found at the top of the latter series in the northern area. For the present, and until the trilobites collected from them have been determined, I propose to call them the Hwe Mawng series, from the village close to which I obtained the finest collection of fossils. These rocks form a broad belt of hilly country to the east of the Naungkangyi band, and have been traced for the same distance.

To the east of these, forming a succession of low foot-hills, bordering the plain of Kehsi Mansam, comes a series of soft sandy marls, of which outcrops are very seldom obtainable. In one of these, however, I found specimens of trilobites with a Silurian facies, and I have little doubt that these marls represent the Namhsim sandstones of the northern area. These soft marls are in turn covered by the Plateau Limestone of the Kehsi Mansam valley, which sweeps round the foot of the high range from the north, and occupies all the low ground.

The western side of the range differs from that just described in the absence of the Hwe Mawng and Naungkangyi series. Here the soft sandy marls containing Silurian trilobites rest directly upon the sandstones of the Loi Twang series, or more probably are faulted against them. They are in turn overlaid by the Plateau Limestones, which form the small plateau of Loi Keng (21° 58′ : 97° 39′).

Mode of occurrence of the gold.

The gold of this district is derived entirely from the sandstones of the Loi Twang series, but judging from the capricious nature of its occurrence in the streams draining the sandstones, its distribution in the rock must be very irregular. I could find no trace of igneous intrusion which would account for the mineralisation of the sandstones, and it seems to me very probable that the gold was introduced during the deposition of the latter from some outside source, perhaps from the crystalline rocks to the north. The gold is usually found in thin flat spangles with very irregular outlines and a pitted surface, as if it had segregated in the interstices between the sand-grains, and the only "nugget" found during my investigation shows that the matrix was of a sandy nature. It is found in all the streams which radiate from the Loi Twang ridge, except those whose valleys are mainly confined to the shales associated with the sandstones. The fact that the gold occurs in this sandy series is of considerable interest, for rocks of the same appearance and probably of the same age are found in several parts of the N. Shan States and it is not unlikely that the gold reported to occur in many localities in those States is derived from them. In any case the streams that drain these rocks, wherever they are found, would be worth prospecting. From all I can gather the gold now being mined at Namma is probably derived from similar rocks.

The streams were examined in order, beginning at the north end of the range, and working round by the east to the south-west. In most cases very little gold was found in the gravel now brought down by the streams, in fact as a general rule they are too feeble to transport gravel of any size more than a very short distance from the mouths of the narrow ravines cut through the solid rocks of the range. The only exception is the Nam Ka, which drains the western side of the range, and is a fair-sized stream. In this case coarse gold is found in the present bed of the stream as far down as Hamngai, about six miles from its source. In the other cases the gold was found in the older alluvium underlying the stream beds, evidently laid down, judging from the size of the boulders usually found in it, at a time when the streams had far greater transporting power than they now possess. In taking samples pits were dug as far as possible into the gravel deposits, and 6 cubic feet were measured out in each case and washed under my personal supervision. The resulting concentrates were preserved for assay in the laboratory. In most cases the influx of water was so great on reaching the gravel that the pits could not be carried more than 3 feet or so into it, and it was very seldom that the bed rock was reached. The samples collected therefore only give a rough idea of the value of the gravels, but they are sufficient to show that the field as a whole is of no value from a commercial point of view.

Results of assays.

The results of the examination of the concentrates in the laboratory have proved to be very disappointing in view of the hopes raised by the coarseness and quantity of the gold in the samples originally collected by the Sawbwa of Hsipaw. In only five instances did the value of the gold per cubic yard amount to more than one grain of gold, and in the great majority of pits only a trace of gold was found, in exceedingly fine particles. The coarsegold was found in only a few of the pits, and it is because these spots were known to the natives that the Sawbwa was able to obtain so much gold with so little labour. Even if these spots were much richer than they are the field would be not worth working as a mining proposition, and the gold that does exist may safely be left to the natives, for extraction by their primitive methods of washing.

The streams examined were:—

Möng Tung Sub-State.

I. *Hwe-long* (Plan A). This stream issues from the hills 2 miles to the S. S. W. of Möng Tung, and drains the northern end of the Loi Twang range. Four pits were sunk along the course of the stream below the point where it issues from a narrow ravine, of which Nos. 1 and 3 showed very slight traces of gold, but none was found in Nos. 4 and 5. Sample No. 2 was taken from a gravel spit on the bank of the stream, and showed a colour. Two pits were also put down on a terrace of older alluvium bordering the stream, and gravel was met with in both, but only the lower stratum in No. 7, 7 ft. 6 ins. from the surface, gave a colour. About a quarter of a mile higher up stream the valley opens out, and a deposit of coarse gravel and boulders was found with a cover of 3 to 4 ft. of soil and clay. Three pits were sunk into this, but none of them showed the slightest trace of gold. Nearly all the pebbles in this gravel were of shale. The gold lower down was apparently derived from a band of the sandstones which crosses the stream between the two gravel deposits.

II. *Namhkam* (Plans B and C). The Namhkam (Golden stream) issues from a narrow gorge close to the village of Wan Maü, 3 miles S. E. of Möng Tung. Two areas of auriferous gravel in this stream were examined.—

(1) *Lower Namhkam* (Plan B). The gravel deposit here is covered by from 3 to 8 ft. of soil and clay, and the whole of the ground is cultivated. Nine pits were sunk, of which eight produced gold. In the upper pits, Nos. 1 to 4 and 6, the gold was fairly coarse, but lower down it became progressively finer in grain, and in pit No. 9, the lowest, it occurred only in microscopic particles. It is probable that it does not extend much below this.

(2) *Upper Namkham* (Plan C). This is a small patch of coarse gravel and boulders occupying a slightly wider part of the gorge, where a band of shale crosses the stream, about half a mile above Lower Namhkam. Here there is no 'cover' to the deposit, or at most 8 inches or so of soil. Gold was found in 4 out of 5 pits sunk. The thickness of the deposit is about 2 ft. resting on decomposed shales. The only nugget found during the operations was obtained from the lowest pit, No. 1, in this deposit. Its weight is 4·86 grains.

III. *Hwe-pan-hak.* This stream drains the S. E. side of the same ridge as the Namhkam, but no trace of gold was found either in the bed of the stream, or in the older gravel deposited by it. The eastern branch also of this stream contained no gold.

Kehsi Mansam Sub-State.

Passing now to the eastern side of the range, four streams were examined, with the following results:—

IV. *Hwe Patayap.* One of the pits put down on this stream showed a very thin stratum of fine gravel containing a few extremely minute specks of gold. The others met with either quicksand or clay. The valley appears to be excavated mainly in shales.

V. *Hwe Nying.* In two pits sunk near the stream coarse gravel with boulders was found containing a small quantity of gold in fine particles. The coarseness of the gold was not found to increase higher up the valley, and the average value of the deposit is very small.

VI. *Hwe Mawng.* The same remarks apply to this stream as to the last. Gold was found only in one pit near the point where the stream issues from a deep narrow gorge, in small quantity and only in very fine particles.

VII. *Hwe Aw* (Plan D). This is the stream referred to in the correspondence on this subject as the Hwe Mawng, from which the Sawbwa of Hsipaw is said to have obtained a nugget weighing 117·55 grains. It drains the southern end of the Loi Twang range, and is the only stream on this side which carries gold in any quantity. Twelve pits were sunk along the course of the stream, ten of which produced gold, but its distribution is somewhat capricious. The most productive pits were those on the lower part of the stream below the point marked A on the plan, where it flows through a narrow gorge formed of sandstone. In the lowest pit, No. 1, a few fine particles only were found, but in the four pits, Nos. 2-5, above this, it occurred in comparatively large flakes or spangles, showing no signs of being waterworn. A pit sunk in the middle of the gorge mentioned above met with very large boulders and sand, but no gold. The two pits above this, Nos. 6 and 7, gave only fine particles, but in No. 8 fairly coarse gold was again found. Higher up again in pits 9 and 10, there was very little gold, and that only in minute particles.

VIII. *Namkat.* Four pits were put down in the valley of this stream, which is a tributary of the Hwe Aw, but none of them showed any trace of gold.

The valleys of all these streams are of the same character, narrow, rather highly inclined, and, with the exception of the Hwe Aw, nearly straight. They are all cultivated, with a very elaborate system of terracing, and the amount of waste ground is confined to a few feet on either side of the stream bed. The flow of water in the streams is inconsiderable, and none of them are able to transport even fine gravel to any distance from the points where they issue from the deep narrow ravines on the flanks of the main range. It is very doubtful whether there would be sufficient water in any of them to work the deposits, except on a very small scale, even if a far larger amount of gold were present than is actually the case.

Möng Küng Sub-State.

IX. *Nam Ka* (Plan E). This stream, with its tributaries, drains the whole of the western flank of Loi Twang, and differs from those already mentioned in possessing a wide level valley and a considerable flow of water. Gold was found both in the bed of the river and in the older gravels as far down as Hamngai, about six miles from its source, but in only one instance did it appear to be fairly abundant and in coarse flakes. Eighteen pits were sunk along or near the course of the river between Hamngai and Wan-tawng, about four miles up stream. In some of these nothing was met with but quicksand with a copious discharge of water, and the gravel deposit could not be reached with the appliances at my disposal. Gold was found wherever coarse gravel was reached as far up as the mouth of a small stream, about a mile south of Wan-tawng, draining the southern end of Loi Twang, but above this, in the main stream, either no gold at all, or only a few microscopic particles. A couple of pits, sunk along the small stream referred to, also showed no gold. The absence of gold above Wan-tawng may be accounted for by the fact that the course of the stream above this point lies mainly through limestone.

There is a fairly large flow of water in the Nam Ka at Hamngai, probably sufficient for dredging, but it is doubtful whether it could be obtained under sufficient pressure higher up stream for hydraulic mining, except at great expense. As in the case of the other streams examined, the whole of the ground overlying the deposit is terraced and cultivated.

Summary.

The general results of my examination of this gold-field are given in the following table, from which it will be seen that only in three of the streams, *viz.*, the Namhkam in Möng Tung, the Hwe Aw in Kehsi Mansam, and the Nam Ka in Möng Küng, was coarse gold found, and that even in these it is confined to a very small area in each case. It is possible that further prospecting might reveal the presence of gold in larger quantities in the lower portion of the gravel deposits, which was not reached in most of the pits sunk by me, but so far as I could judge this was not the case in the few instances where the pits reached the bed rock. In any case I think that further prospecting might well be left to private enterprise. Even if the value of the deposits were proved to be greater than it seems to be, a serious objection to their being worked on a large scale is undoubtedly the fact that the gold-bearing gravels are in all cases covered by a fertile soil which is terraced and cultivated, and that practically the whole of this cultivation would be destroyed by the operations. In the Hwe Aw valley this terracing is carried to a considerable height up the hill sides, which are very steep, and even if the excavations were confined to the narrow strip of waste ground immediately adjoining the stream, there is little doubt that any interference with the base of the slopes would eventually result in the destruction of the terraces above. On the Nam Ka the damage done need not be so complete, for the valley is more open, but certainly more than half the present cultivated area would have to go. In these two cases the area cultivated has reached its possible limits and the villages dependent on it would have to be abandoned. These would be—on the Hwe Aw, Kong-mu, Ho-hkai, Kong-lang, and perhaps Ho-na: and on the Nam Ka, Hamngai, Hai-kun, Kyawng-pong, and perhaps Wan-tawng, all of which are large and thriving villages. Moreover, there is no waste land in the neighbourhood to which these villages could be removed. In the case of the Namhkam the problem is not so difficult, for only one large village, Wan Maü, would be affected, and there is a considerable amount of waste but cultivable land available in the neighbourhood of this village. It is, however, hardly probable that the question will arise, for the general value of the deposits is so low that it is not likely that any application will be made for working them on a large scale.

SUB-STATE.	Name of stream.	Area of deposit.	No. of pit.	Depth of gravel from surface.	Thickness of gravel.	Character of deposit.	Value of gold per cubic yard.
		Acres.		*ft. ins.*	*ft. ins.*		*Grains.*
MÖNG TUNG.	I. Hwelong . . .	$2\frac{1}{3}$	1	1 0	3 6	Coarse gravel and small boulders	0·09
			2	...	1 0+	Coarse gravel	Trace.
			3	3 0	2 0	Do.	*Nil.*
			4	4 0	2 0+	Coarse gravel mostly shale pebbles.	Trace.
			5	4 6	2 0	Do. do.	*Nil.*
			6	7 6	2 0	Do. do.	*Nil.*
			7	6 0	2 0	Do. do.	*Nil.*
	II. Namhkam—						
	(i) Lower Namhkam	$17\frac{1}{3}$	1	8 0	2 0+	Coarse gravel with small boulders	0·09
			2	6 0	2 0+	Do. do.	0·135
			3	6 0	1 0+	Do. do.	0·09
			4	4 6 to 6 0	1 0 to 4 0	Coarse gravel with large boulders	0·225

SUB-STATE.	Name of stream.	Area of deposit.	No. of pit.	Depth of gravel from surface.	Thickness of gravel.	Character of deposit.	Value of gold per cubic yard.
MÖNG TUNG—*concld.*	II. Namhkam—	*Acres.*		*ft. ins.*	*ft. ins.*		*Grains.*
	(i) Lower Namhkam —*concld.*	...	5	6 0	2 0+	Coarse gravel with large boulders	Trace.
			6	7 0	2 6+	Coarse gravel with small boulders	1·08
			7	3 0	2 6	Coarse gravel	Trace.
			8	7 6	2 0+	Do.	0·18
			9	9 0	2 6+	Do.	Trace.
	(ii) Upper Namhkam	1⅓	1	0 8	2 0	Do.	22·14
			2	0 8	2 0	Do.	0·36
			3	2 0	2 0	Do.	Trace.
			4	...	2 0	Earthy gravel	*Nil.*
			5	1 0	4 0	Coarse gravel	Trace.
			6	...	...	Do.	*Nil.*
	III. Hwe-pan-hak .	...	1	...	6 0	Sand and gravel . . .	*Nil.*

SUB-STATE.	Name of stream.	Area of deposit.	No. of pit.	Depth of gravel from surface.	Thickness of gravel.	Character of deposit.	Value of gold per cubic yard.
		Acres.		*ft. ins.*	*ft. ins.*		*Grains.*
KEHSI MANSAM.	IV. Hwe Patayap	...	1	4 0	1 0	Fine gravel	Trace.
			2	10 0	No gravel	......	*Nil.*
	V. Hwe Nying	...	1	3 6	1 6	Coarse gravel and boulders	Trace.
			2	2 6	2 0	Do. do.	Do.
			3	2 0	2 0	Do. do.	Do.
	VI. Hwe Mawng	...	1	3 9	2 0+	Do. do.	Do.
			2	5 0	2 0	Do. do.	*Nil.*
	VII. Hwe Aw	203	1	1 0	2 0 to 3 0	Coarse gravel	Trace.
			2	2 0	2 0+	Coarse gravel with small boulders	0·27
			3	0 6	2 0+	Do. do.	0·675
			4	2 6	2 0+	Do. do.	0·09
			5	2 6	2 0+	Do. do.	1·575
			6	2 0	2 0+	Do. do.	Trace.

SUB-STATE.	Name of stream.	Area of deposit.	No. of pit.	Depth of gravel from surface.	Thickness of gravel.	Character of deposit.	Value of gold per cubic yard.
		Acres.		*ft. ins.*	*ft. ins.*		*Grains.*
KEHSI MANSAM—*concld.*	VII. Hwe Aw—*concld*	...	7	3 0	2 0+	Coarse gravel with small boulders	0·09
			8	5 0	1 6	Do. do.	1·305
			9	3 6	2 0+	Do. do.	Trace.
			10	2 0	2 0+	Do. do.	Do.
	VIII. Namkat	...	1	3 0	1 0	Do. do.	*Nil.*
			2	2 0	2 0	Do do.	*Nil.*
MÖNG KÜNG.	IX. Nam Ka	776	1	8 6	3 0	Do. do.	0·315
			2	10 0	3 0+	Fine gravel	Trace.
			3	10 0	3 0	Coarse gravel with small boulders	1·89
			4	11 0	3 0	Do. do.	Trace.
			5	4 0	2 6+	Do. do.	Do.
			6	4 0	2 0+	Do. do.	Do.
			7	5 6	4 0+	Do. do.	0·135

NOTE ON THE OCCURRENCE OF *Physa Prinsepii* IN THE MAESTRICHTIAN STRATA OF BALŪCHISTĀN. BY ERNEST W. VREDENBURG, A.R.C.S., A.R.S.M., *Geological Survey of India.*

IN the absence of direct evidence, the Upper Cretaceous age generally attributed to the Deccan Trap in the publications of the Geological Survey of India has remained for a long time rather conjectural, and it is gratifying to find that of late years we have become acquainted with palæontological data confirming this conclusion, and defining with some degree of accuracy the horizon of the great volcanic formation. *Cardita Beaumonti* d'Arch. and Haime, one of the leading fossils of the strata associated with the Deccan Trap in Sind, has been obtained in Luristān by de Morgan in beds containing the genera *Omphalocyclus* and *Hippurites*,[1] while in Egypt, the same fossil, or one closely allied, described under the name of *Cardita Lybica* Zittel, occurs both in the Maestrichtian beds with *Ostrea Overwegi* Buch, *Indoceras Ismaelis* Zittel, *Baculites anceps* Lamk., etc., and in the overlying Danian beds with *Nautilus Danicus* Schloth.[2] The Maestrichtian beds of Luristān also contain *Cerithium Stoddardi* Hislop, and *Irania fusiformis* Hisl.[3] which characterise the Intertrappean beds of Rājāmahendri. A further piece of evidence is now supplied by the recognition, amongst beds of the same age in Balūchistān, of the characteristic Intertrappean fossil, *Physa Prinsepii* Sowerby.

This fossil was recognised amidst some specimens collected by Dr. Noetling in the Des valley of the Mari country in Balūchistān during the year 1898. The collection is very interesting on account of the great number of fossiliferous horizons that succeed one another in one continuous section. A short account of the stratigraphy and palæontology of the Des valley was published by Dr. Noetling in the General Report of the Geological Survey for 1898-1899,[4] and again

[1] Mission J. de Morgan, Paléontologie; Mollusques fossiles par H. Douvillé, Paris, 1904.

[2] A. Quaas: Die Fauna der Overwegischichten und der Blätterthone in der libycshen Wüste. *Palaeontographica*, XXX (2), pp. 153-336, (1902).

[3] *Loc. cit.*, pp. 304 and 321.

[4] Preliminary report on the Mari hills and part of the Zhob valley, pp. 51-63.

in the *Centralblatt für Min., Geol. und Pal.* for 1903.[1] The latter contribution is illustrated with a figured section in which the beds are numbered from 1 to 29, the 24 first zones being regarded as Cretaceous, the remainder as Tertiary. The opinion is expressed that there is a complete gradual transition from Upper Cretaceous to Eocene.

The lists of fossils published in Dr. Noetling's account have no pretence to be complete and only give the names of a few forms that were identified in the field. The *Physa* which I look upon as identical with *Ph. Prinsepii* is not mentioned in Dr. Noetling's lists. It occurs amongst the fossils of zone 20 in company with a number of interesting forms, amongst which may be mentioned *Sphenodiscus Ubaghsi* de Grossouvre, a characteristic species of the newest ammonite zones of Europe. The rock constituting zone 20 is an olive-coloured shale impregnated with volcanic material. It is mostly unfossiliferous except for some very thin bands of hardened calcareous somewhat porcellanic-looking material in which the fossils occur surrounded by concretions not unlike those enclosing the ammonites of the Spiti shales. Owing to its well-marked lithology and its stratigraphical relation to the underlying and overlying fossiliferous horizons, the same zone is readily identified in the State of Kelāt where I have found it crowded with specimens of *Sph. Ubaghsi* accompanied by other ammonites identified as *Pachydiscus Neubergicus* F. Von Hauer, *Pach.* n. sp., *Schlüteria Larteti* Seunes, and *Baculites* sp. In Dr. Noetling's collection *Sphenodiscus Ubaghsi* is represented by a single very well preserved specimen of which special mention is made in the General Report for 1898-1899, page 56, where it is erroneously referred to *Indoceras baluchistanense* Noetl. which it closely resembles when, as in the present case, the shell is well preserved. On closely examining the specimen I found the sutures clearly exhibited over a portion where the shell is missing, and they agree with those of the numerous specimens which I obtained at the same horizon in the neighbourhood of Kelāt. As already mentioned, Dr. Noetling's preliminary lists are founded on identifications roughly made in the field.

Dr. Noetling's collection from this zone contains three specimens of *Physa* measuring about 55, 50, and 28 millimetres in length,

[1] Uebergang zwischen Kreide und Eocän in Balūchistān, pp. 514-523.

respectively. The shape of the two larger specimens agrees in every particular with the specimens of *Physa Prinsepii* Sow. from the Intertrappeans of the Indian Peninsula, belonging to the form distinguished by Hislop as the "normal" one. (*Quart. Journ. Geol. Soc.*, Vol. XVI, p. 173, Pl. V, fig. 23*a*, 1859.) The two larger specimens show very clearly the distinctive specific character constituted by the large size of the last whorl enveloping the greater part of the younger portion of the shell, with the consequent development of an aperture of considerable height relatively to the spire. The smallest specimen agrees in the greater relative length of the spire with the immature individual figured by Hislop (*loc. cit.* Pl. V, fig. 23*c*) and referred to the variety *elongata*. The largest of the Balūchistān specimens does not attain the size frequently exhibited by those from the Peninsula. Either the Balūchistān ones belong to a smaller race, or the difference may be simply accidental in consequence of the small number of specimens obtained. The fauna of zone 20 is chiefly marine, and the individuals of *Physa* must have been washed into the sea from some neighbouring estuary. This probably happened only during exceptional floods, and the individuals of various sizes thus overwhelmed could not have survived the altered conditions to which they were accidentally subjected. We cannot expect therefore to find such a preponderance of full-grown specimens as where the conditions of life were so eminently favourable as they seem to have been in the Intertrappean swamps.

But for the unimportant difference in size, the Des valley specimens do not exhibit the slightest divergence from the peninsular Intertrappean ones, nor do they show any approach towards the European fossil forms of which I have been able to consult descriptions. The overlapping disposition of the last whorl is even better marked than in some peninsular specimens.

The zones distinguished by Dr. Noetling as the "Hemipneustes beds" constituting horizons 2 to 12 in the Des valley section, and recognisable in many parts of Balūchistān, do not contain any intercalations of volcanic material. It is only when we reach the horizon of the olive shales that contemporaneous volcanic action becomes evident. While examining Dr. Noetling's collection I was able to identify several foraminifera which are of assistance in estimating the age of the various zones. The species referred by Dr. Noetling to *Orbitoides socialis* Leym (Upper Cretaceous fauna of Balūchistān, *Pal. Ind.*, ser. XVI, Pl. I, figs. 1-4, 1897) is in reality *O. media* d'Arch. It occurs in zone 7 together with a small form of *Omphalocyclus.* Specimens identical with the true *Orbitoides socialis* also occur, but at a higher horizon in zone 11, in company with a rich fauna amongst which mention may be made of a *Sphenodiscus* closely allied to *Sph. Shiva* Forbes of the Valudayur beds of Southern India, and to *Sph. lenticularis* Meek of the "Fox Hills group" of North America. Typical specimens of *Omphalocyclus macropora* Leym occur plentifully in zone 16.

Dr. Noetling has classified all the beds of the Des valley, from 2 to 18, as Maestrichtian. If we consider that, in Europe, *Orbitoides media* is specially abundant at the limit of the Campanian and Maestrichtian, it seems possible that the lower zones of the Des valley section, from 2 to 4 or 6, may be referable to the Campanian. Zones 19 to 24 have been placed by Dr. Noetling in a special stage styled by him "Pathanian," and regarded as newer than the rocks usually classified as Maestrichtian. Their fauna, nevertheless, indicates an upper Maestrichtian age, at least up to zone 23. Should the uppermost bed, zone 24, turn out to be post-Maestrichtian, there is no need to apply to it any other name but the well-known term "Danian."

Instead of the somewhat vague reference to Upper Cretaceous or Lower Tertiary with which we had formerly to be content as regards the age of the Deccan Trap, we are now in possession of a certain amount of sound palæontological data fixing the age of a portion of the volcanic outbursts as Maestrichtian, the eruptions continuing, no doubt, into the Danian. We do not know of any undoubted instance of their having extended into the Eocene. In Sind, where the oldest Tertiary beds of India are exposed, there is a stratigraphical gap between the last eruptions and the very early Eocene beds at the base of the Ranikot.

Regarding Dr. Noetling's claim as to the presence of passage beds between Cretaceous and Tertiary in the Des valley section, it may be mentioned that in the State of Kelāt, the olive shales with *Sphenodiscus Ubaghsi* are succeeded by a vast thickness of sandstones which I propose to distinguish as the "Pab sandstones," and which correspond with the thick "*Cardita Beaumonti* group" of Sind. In the latter province this formation is unconformably overlaid by the Lower Ranikot whose age approximately corresponds with that of the Woolwich and Reading beds. This is succeeded by the Upper Ranikot corresponding with the London Clay and the nummulitic sands of Cuise, and this in its turn by the Laki series of Lower Lutetian age. In the Des valley section, the Pab sandstones are reduced to a thin layer (zone 24) probably corresponding with their lowermost beds. The next fossiliferous zone, 100 feet higher, corresponds with the Laki limestone, the intervening unfossiliferous beds being apparently connected with it. The greater part of the Pab sandstones, and the whole of the Lower and Upper Ranikot are therefore missing, and the claim to the Des valley section representing a gradual transition from Cretaceous to Tertiary cannot therefore be substantiated.

MISCELLANEOUS NOTES.

Further note on the Trias of Lower Burma and on the occurrence of *Cardita Beaumonti* d'Arch. in Lower Burma.

IN a preliminary note on the Trias of Lower Burma (*Rec. G. S. I.*, Vol. XXXIV, pt. 2, p. 134), I gave reasons for supposing that true Triassic rocks do occur in the Arrakan Yoma. Further investigation shows that the Axial (Triassic) group of Theobald is a complex one, and that he classed together beds of very different ages. Theobald (*Mem. G. S. I.*, Vol. X, pt. 2, p. 134) divided his Trias into two groups, which may be summarised as follows :—

Upper Axials . .	*a.* Cardita beds.
	b. Halobia limestones.
	c. Shales, sandstones and grits.
Lower „ . .	Flaggy shales and sandstones.

The Halobia limestones were dealt with in part in the note referred to above. It is with the Cardita beds that this short note is concerned. The fossils from these beds were discovered in the Museum unregistered but labelled by Theobald himself as Triassic. They consist chiefly of fairly well preserved *Carditæ* and some poor gastropods (*Turritella*, etc.). The *Carditæ* are all of one species, and are easily recognised as identical with the well-known *Cardita* (*Venericardia*) *Beaumonti* d'Arch. of Sind and Baluchistán. Beds with *C. Beaumonti* have long been supposed to bridge over the gap between the Tertiary and the Cretaceous, but they are more probably Maestrichtian to perhaps Lower Danian in age. (Vredenburg, *Rec. G. S. I.*, Vol. XXXIV, pt. 2, p. 86.) Theobald was aware of the occurrence of Cretaceous rocks in the Arrakan Yoma from the discovery of a fragment of a Cenomanian ammonite (*Schlœnbachia inflata*) near Maũ, but he did not suspect the Cretaceous age of these Cardita beds. It is very evident that Theobald's Axial (Triassic) group is a very mixed one, containing not only Triassic rocks, but also beds of Cretaceous age.

[G. H. TIPPER.]

Fossils in the Upper Miocene of the Yenangyaung Oil-field, Upper Burma.

Until quite recently, the only fossils found in the Upper Miocene or Yenangyaung stage in the Miocene outcrop at Yenangyaung, consisted of three species of *Batissa (Cyrena)* described by Dr. Noetling[1] under the names of *B. kodaungensis*, *B. crawfurdi*, and *B. petrolei*. The corresponding strata at Singu and Yenangyat contain a typical marine fauna, and it was therefore concluded by Dr. Noetling[2] that the Yenangyaung beds of Burma occurred in two facies, a marine type at Singu, Yenangyat and Minbu, and an estuarine type at Yenangyaung. He mentions the abundance of gypsum in the latter locality in support of this view, and considers that the one type of beds passes horizontally into the other.

The discovery of a number of marine fossils in this stage a short distance north of the village of West Twingon, Yenangyaung, shows that the change from estuarine to marine conditions—assuming that the southern part of the Yenangyaung outcrop does consist of estuarine beds—commences at least as far south as this village. The fossils were found in a hard limestone about 1 foot thick and of very limited horizontal extent: they extend sparingly for a short distance into the underlying soft sandstone and into the overlying mixture of sand and clay lenticles. The horizon of the bed is about 350 feet below the ferruginous conglomerate or Pliocene-Miocene boundary. The fossils, some of which show compressional distortion, are imperfectly preserved in the sands and clays, and difficult to extract from the limestone. It should be mentioned that gypsum is quite as abundant at Singu and Yenangyat as at Yenangyaung; but it is probably subsequent to the Miocene.

[E. H. PASCOE.]

Note on a cranium of *Boselaphus namadicus* Rütim. from the Narbada Pleistocene gravels of Jabalpur.

In the course of an examination of the collections of the Nagpur Museum some months ago, I came across a well preserved fragment of the cranium of *Boselaphus namadicus* Rütim. showing the occipital,

[1] Fauna of the Miocene Beds of Burma, *Palæontologia Indica*, New Series Vols. 1-3, page 183.

[2] *Ibid*, page 9.

parietal and frontal regions. The only known examples of this species exist in the British Museum, and were figured and briefly described by Rütimeyer[1] in 1878. Lydekker refers to these specimens in *Pal. Ind.*, ser. X, Vol. III, p. 48 (1885).

The present specimen is an almost exactly similar fragment to those in the British Museum, except for the absence of the horn cores. Both of them unfortunately lack the teeth, but there can be no doubt as to specific identity. They differ from the corresponding portions of the recent Nylgai, *Boselaphus Pragscamelus*, chiefly in the greater approximation of the horn cores to the orbit.

This species has accidentally been omitted from the list of the Narbada pleistocene vertebrate fauna given in the Manual of Indian Geology, 2nd ed., p. 398 (1892).

The Nagpur Department of Agriculture have presented the specimen to the Geological Survey and it is now stored in the Geological Museum, Calcutta (Reg. No. K $\frac{9}{739}$.)

[GUY E. PILGRIM.]

[1] Abh. schwoiz. pal. Geo., Vol. V, p. 89 (1878).

Part 3.—Note on the progress of the gold industry in Wynaad, Nilgiri district. Notes on the representatives of the Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

Part 4.—On the geographical distribution of fossil organisms in India. Submerged forest on Bombay Island.

VOL. XII, 1879.

Part 1.—Annual report for 1878. Geology of Kashmir (third notice). Further notices of Siwalik mammalia. Notes on some Siwalik birds. Notes of a tour through Hangrang and Spiti. On a recent mud eruption in Ramri Island (Arakan). On Braunite, with Rhodonite, from near Nagpur, Central Provinces. Palæontological notes from the Satpura coal-basin. Statistics of coal importations into India.

Part 2.—On the Mohpani coal-field. On Pyrolusite with Psilomelane occurring at Gosalpur, Jabalpur district. A geological reconnaissance from the Indus at Kushalgarh to the Kurram at Thal on the Afghan frontier. Further notes on the geology of the Upper Punjab.

Part 3.—On the geological features of the northern part of Madura district, the Pudukota State, and the southern parts of the Tanjore and Trichinopoly districts included within the limits of sheet 80 of the Indian Atlas. Rough notes on the cretaceous fossils from Trichinopoly district, collected in 1877-78. Notes on the genus Sphenophyllum and other Equisetaceæ, with reference to the Indian form Trizygia Speciosa, Royle (Sphenophyllum Trizygia, Ung.). On Mysorin and Atacamite from the Nellore district. On corundum from the Khasi Hills. On the Joga neighbourhood and old mines on the Nerbudda.

Part 4.—On the 'Attock Slates' and their probable geological position. On a marginal bone of an undescribed tortoise, from the Upper Siwaliks, near Nila, in the Potwar, Punjab. Sketch of the geology of North Arcot district. On the continuation of the road section from Murree to Abbottabad.

VOL. XIII, 1880.

Part 1.—Annual report for 1879. Additional notes on the geology of the Upper Godavari basin in the neighbourhood of Sironcha. Geology of Ladak and neighbouring districts, being fourth notice of geology of Kashmir and neighbouring territories. Teeth of fossil fishes from Ramri Island and the Punjab. Note on the fossil genera Nöggerathia, Stbg., Nöggerathiopsis, Fstm., and Rhiptozamites, Schmalh., in palæozoic and secondary rocks of Europe, Asia, and Australia. Notes on fossil plants from Kattywar, Shekh Budin, and Sirgujah. On volcanic foci of eruption in the Konkan.

Part 2.—Geological notes. Palæontological notes on the lower trias of the Himalayas. On the artesian wells at Pondicherry, and the possibility of finding such sources of water-supply at Madras.

Part 3.—The Kumaun lakes. On the discovery of a celt of palæolithic type in the Punjab. Palæontological notes from the Karharbari and South Rewah coal-fields. Further notes on the correlation of the Gondwana flora with other floras. Additional note on the artesian wells at Pondicherry. Salt in Rajputana. Record of gas and mud eruptions on the Arakan coast on 12th March 1879 and in June 1843.

Part 4.—On some pleistocene deposits of the Northern Punjab, and the evidence they afford of an extreme climate during a portion of that period. Useful minerals of the Arvali region. Further notes on the correlation of the Gondwana flora with that of the Australian coal-bearing system. Note on reh or alkali soils and saline well waters. The re-soils of Upper India. Note on the Naini Tal landslip, 18th September 1880.

VOL. XIV, 1881.

Part 1.—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts, being fifth notice of the geology of Kashmir and neighbouring territories. Note on some Siwalik carnivora. The Siwalik group of the Sub-Himalayan region. On the South Rewah Gondwana basin. On the ferruginous beds associated with the basaltic rocks of north-eastern Ulster, in relation to Indian laterite. On some Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on the lower trias of the Himalayas.' On some mammalian fossils from Perim Island, in the collection of the Bombay Branch of the Royal Asiatic Society.

Part 2.—The Nahan-Siwalik unconformity in the North-western Himalaya. On some Gondwana vertebrates. On the ossiferous beds of Hundes in Tibet. Notes on mining records and the mining record office of Great Britain; and the Coal and Metalliferous Mines Acts of 1872 (England). On cobaltite and danaite from the Khetri mines, Rajputana; with some remarks on Jaipurite (Syepoorite). On the occurrence of zinc ore (Smithsonite and Blende) with barytes, in the Karnul district, Madras. Notice of a mud eruption in the island of Cheduba.

Part 3.—Artesian borings in India. On oligoclase granite at Wangtu on the Sutlej, North-west Himalayas. On a fish-palate from the Siwaliks. Palæontological notes from the Hazaribagh and Lohardagga districts. Undescribed fossil carnivora from the Siwalik hills in the collection of the British Museum.

Part 4.—Remarks on the unification of geological nomenclature and cartography. On the geology of the Arvali region, central and eastern. On a specimen of native antimony obtained at Pulo Obin, near Singapore. On Turgite from the neighbourhood of Juggiapett, Kistnah district, and on zinc carbonate from Karnul, Madras. Note on the section from Dalhousie to Pangi, *viâ* the Sach Pass. On the South Rewah Gondwana basin. Submerged forest on Bombay Island.

Vol. XV, 1882.

Part 1.—Annual report for 1881. Geology of North-west Kashmir and Khagan (being sixth notice of geology of Kashmir and neighbouring territories). On some Gondwana labyrinthodonts. On some Siwalik and Jamna mammals. The geology of Dalhousie, North-west Himalaya. On remains of palm leaves from the (tertiary) Murree and Kasauli beds in India. On Iridosmine from the Noa-Dihing river, Upper Assam, and on Platinum from Chutia Nagpur. On (1) a copper mine lately opened near Yongri hill, in the Darjiling district; (2) arsenical pyrites in the same neighbourhood; (3) kaolin at Darjiling (being 3rd appendix to a report on the geology and mineral resources of the Darjiling district and the Western Duars). Analyses of coal and fire-clay from the Makum coal-field, Upper Assam. Experiments on the coal of Pind Dadun Khan, Salt-range, with reference to the production of gas, made April 29th, 1881. Report on the proceedings and result of the International Geological Congress of Bologna.

Part 2.—General sketch of the geology of the Travancore State. The Warkilli beds and reported associated deposits at Quilon, in Travancore. Note on some Siwalik and Narbada fossils. On the Coal-bearing rocks of the valleys of the Upper Rer and the Mand rivers in Western Chutia Nagpur. On the Pench river coal-field in Chhindwara district, Central Provinces. On borings for coal at Engsein, British Burma. On sapphires recently discovered in the North-west Himálaya. Notice of a recent eruption from one of the mud volcanoes in Cheduba.

Part 3.—Note on the coal of Mach (Much) in the Bolan Pass, and of Sharag or Sharigh on the Harnai route between Sibi and Quetta. New faces observed on crystals of stilbite from the Western Ghâts, Bombay. On the traps of Darang and Mandi in the North-western Himálayas. Further note on the connexion between the Hazara and the Kashmir series. On the Umaria coal-field (South Rewah Gondwana basin). The Daranggiri coal-field, Garo Hills, Assam. On the outcrops of coal in the Myanoung division of the Henzada district.

Part 4.—On a traverse across some gold-fields of Mysore. Record of borings for coal at Beddadanol, Godavari district, in 1874. Note on the supposed occurrence of coal on the Kistna.

Vol. XVI, 1883.

Part 1.—Annual report for 1882. On the genus Richthofenia, Kays (Anomi Lawrenciana, Koninck). On the geology of South Travancore. On the geology of Chamba. On the basalts of Bombay.

Part 2.—Synopsis of the fossil vertebrata of India. On the Bijori Labyrinthodont. On a skull of Hippotherium antilopinum. On the iron ores, and subsidiary materials for the manufacture of iron, in the north-eastern part of the Jabalpur district. On laterite and other manganese ore occurring at Gosulpore, Jabalpur district. Further notes on the Umaria coal-field.

Part 3.—On the microscopic structure of some Dalhousie rocks. On the lavas of Aden. On the probable occurrence of Siwalik strata in China and Japan. On the occurrence of Mastodon angustidens in India. On a traverse between Almora and Mussooree made in October 1882. On the cretaceous coal-measures at Borsora, in the Khasia Hills, near Laour, in Sylhet.

Part 4.—Palæontological notes from the Daltonganj and Hutar coal-fields in Chota Nagpur. On the altered basalts of the Dalhousie region in the North-western Himalayas. On the microscopic structure of some Sub-Himálayan rocks of tertiary age. On the geology of Jaunsar and the Lower Himálayas. On a traverse through the Eastern Khasia, Jaintia, and North Cachar Hills. On native lead from Maulmain and chromite from the Andaman Islands. Notice of a fiery eruption from one of the mud volcanoes of Cheduba Island, Arakan. Notice.—Irrigation from wells in the North-Western Provinces and Oudh.

Vol. XVII, 1884.

Part 1.—Annual report for 1883. Considerations on the smooth-water anchorages or mud banks of Narrakal and Alleppy on the Travancore coast. Rough notes on Billa Surgam and other caves in the Kurnool district. On the geology of the Chuari and Sihunta parganas of Chamba. On the occurrence of the genus Lyttonia, Waagen, in the Kuling series of Kashmir.

Part 2.—Notes on the earthquake of 31st December 1881. On the microscopic structure of some Himalayan granites and gneissose granites. Report on the Chhol coal exploration. On the re-discovery of certain localities for fossils in the Siwalik beds. On some of the mineral resources of the Andaman Islands in the neighbourhood of Port Blair. The intertrappean beds in the Deccan and the Laramie group in western North America.

Part 3.—On the microscopic structure of some Arvali rocks. Section along the Indus from the Peshawar Valley to the Salt-range. On the selection of sites for borings in the Raigarh-Hingir coal-field (first notice). Note on lignite near Raipore, Central Provinces. The Turquoise mines of Nishâpûr, Khorassan. Notice of a further fiery eruption from the Minbyin mud volcano of Cheduba Island, Arakan. Report on the Langrin coal-field, south-west Khasia Hills. Additional notes on the Umaria coal-field.

Part 4.—On the Geology of part of the Gangasulan pargana of British Garhwal. On fragments of slates and schists imbedded in the gneissose granite and granite of the North-west Himalayas. On the geology of the Takht-i-Suleiman. On the smooth-water anchorages of the Travancore coast. On auriferous sands of the Subansiri river, Pondicherry lignite, and phosphatic rocks at Musuri. Work at the Billa Surgam caves.

Vol. XVIII, 1885.

Part 1.—Annual report for 1884. On the country between the Singareni coal-field and the Kistna river. Geological sketch of the country between the Singareni coal-field and Hyderabad. On coal and limestone in the Doigrung river, near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field notes.

Part 2.—A fossiliferous series in the Lower Himálaya, Garhwal. On the probable age of the Mandhali series in the Lower Himálaya. On a second species of Siwalik camel (Camelus Antiquus, nobis ex Falc. and Caut. MS.). On the Geology of Chamba. On the probability of obtaining water by means of artesian wells in the plains of Upper India. Further considerations upon artesian sources in the plains of Upper India. On the geology of the Aka Hills. On the alleged tendency of the Arakan mud volcanoes to burst into eruption most frequently during the rains. Analyses of phosphatic nodules and rock from Mussooree.

Part 3.—On the Geology of the Andaman Islands. On a third species of Merycopotamus. Some observations on percolation as affected by current. Notice of the Pirthalla and Chandpur meteorites. Report on the oil-wells and coal in the Thayetmyo district, British Burma. On some antimony deposits in the Maulmain district. On the Kashmir earthquake of 30th May 1885. On the Bengal earthquake of 14th July 1885.

Part 4.—Geological work in the Chhattisgarh division of the Central Provinces. On the Bengal earthquake of July 14th, 1885. On the Kashmir earthquake of 30th May 1885. On the results of Mr. H. B. Foote's further excavations in the Billa Surgam caves. On the mineral hitherto known as Nepaulite. Notice of the Sabetmahet meteorite.

Vol. XIX, 1886.

Part 1.—Annual report for 1885. On the International Geological Congress of Berlin. On some Palæozoic Fossils recently collected by Dr. H. Warth, in the Olive group of the Salt-range. On the correlation of the Indian and Australian coal-bearing beds. Afghan and Persian Field notes. On the section from Simla to Wangtu, and on the petrological character of the Amphibolites and Quartz Diorites of the Sutlej valley.

Part 2.—On the Geology of parts of Bellary and Anantapur districts. Geology of the Upper Dehing basin in the Singpho Hills. On the microscopic characters of some eruptive rocks from the Central Himálayas. Preliminary note on the Mammalia of the Karnul Caves. Memorandum on the prospects of finding coal in Western Rajputana. Note on the Olive group of the Salt-range. On the discussion regarding the boulder-beds of the Salt range. On the Gondwana Homotaxis.

Part 3.—Geological sketch of the Vizagapatam district, Madras. Preliminary note on the geology of Northern Jesalmer. On the microscopic structure of some specimens of the Malani rocks of the Arvali region. On the Malanjkhandi copper-ore in the Balaghat district, C. P.

Part 4.—On the occurrence of petroleum in India. On the petroleum exploration at Khátan. Boring exploration in the Chhattisgarh coal-fields. Field-notes from Afghanistan: No. 3, Turkistan. Notice of a fiery eruption from one of the mud volcanoes of Cheduba Island, Arakan. Notice of the Nammianthal aerolite. Analysis of gold dust from the Meza valley, Upper Burma.

Vol. XX, 1887.

Part 1.—Annual report for 1886. Field-notes from Afghanistan: No. 4, from Turkistan to India. Physical geology of West British Garhwal; with notes on a route traversed through Jaunsar-Bawar and Tiri-Garhwal. On the geology of the Garo Hills. On some Indian image-stones. On soundings recently taken off Barren Island and Narcondam. On a character of the Talchir boulder-beds. Analysis of Phosphatic Nodules from the Salt-range, Punjab.

Part 2.—The fossil vertebrata of India. On the Echinoidea of the cretaceous series of the Lower Narbada Valley, with remarks upon their geological age. Field-notes: No. 5—to accompany a geological sketch map of Afghanistan and North-eastern Khorassan. On the microscopic structure of some specimens of the Rajmahal and Deccan traps. On the Dolerite of the Chor. On the identity of the Olive series in the east with the speckled sandstone in the west of the Salt-range in the Punjab.

Part 3.—The retirement of Mr. Medlicott. Notice of J. B. Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun, Section I. Preliminary sketch of the geology of Simla and Jutogh. Note on the 'Lalitpur' meteorite.

Part 4.—Note on some points in Himálayan geology. Crystalline and metamorphic rocks of the Lower Himálaya, Garhwal, and Kumaun, Section II. The iron industry of the western portion of the District of Raipur. Notes on Upper Burma. Boring exploration in the Chhattisgarh coal-fields. (Second notice.) Some remarks on Pressure Metamorphism, with reference to the foliation of the Himálayan Gneissose Granite. A list and index of papers on Himálayan Geology and Microscopic Petrology, published in the preceding volumes of the Records of the Geological Survey of India.

Vol. XXI, 1888.

Part 1.—Annual report for 1887. Crystalline and metamorphic rocks of the Lower Himálaya, Garhwal, and Kumaun, Section III. The Birds'-nest or Elephant Island, Mergui Archipelago. Memorandum on the results of an exploration of Jessalmer, with a view to the discovery of coal. A facetted pebble from the boulder bed ('speckled sandstone') of Mount Chel in the Salt-range in the Punjab. Examination of nodular stones obtained by trawling off Colombo.

Part 2.—Award of the Wollaston Gold Medal, Geological Society of London, 1888. The Dharwar System, the chief auriferous rock series in South India. On the Igneous rocks of the districts of Raipur and Balaghat, Central Provinces. On the Sangar Marg and Mehowgale coal-fields, Kashmir.

Part 3.—The Manganese Iron and Manganese Ores of Jabalpur. 'The Carboniferous Glacial Period.' The sequence and correlation of the pre-tertiary sedimentary formations of the Simla region of the Lower Himálayas.

Part 4.—On Indian fossil vertebrates. On the geology of the North-west Himalayas. On blown-sand rock sculpture. Re-discovery of Nummulites in Zanskar. On some mica traps from Barakar and Raniganj.

Vol. XXII, 1889.

Part 1.—Annual report for 1888. The Dharwar System, the chief auriferous rock-series in South India. (Second notice.) On the Wajra Karur diamonds, and on M. Chaper's alleged discovery of diamonds in pegmatite near that place. On the generic position of the so-called Plesiosaurus Indicus. On flexible sandstone or Itacolumite, with special reference to its nature and mode of occurrence in India, and the cause of its flexibility. On Siwalik and Narbada Chelonia.

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 4.] **1907.** **[September.**

A PRELIMINARY SURVEY OF CERTAIN GLACIERS IN THE NORTH-WEST HIMALAYA. BY OFFICERS OF THE *Geological Survey of India* (*continued*).

B.—NOTES ON CERTAIN GLACIERS IN LAHAUL. BY H. WALKER, A.R.C.S., F.G.S., A. INST. M.M., AND E. H. PASCOE, M.A., B.SC. (With Plates 40 to 46, 60 and 61.)

INTRODUCTION.

Glaciers visited.

THE glaciers of Lahaul were visited in September, 1906, when observations were made on the Sonápáni (Lat. 32° 25′; Long. 77° 25′) and on the Bara Shigri (Lat. 32° 16′; Long. 77° 39′). The glaciers under notice lie on opposite banks of the Chandra river above its junction with the Bhága river.

Route.

Lahaul is most conveniently reached from Sultánpur, the capital of Kúlú—by one of two passes, *viz.*, the Rhotang, 13,500 feet, or the Hamta, 14,000 feet in height. The former is served by coolies from Rálá which is three stages north of Sultánpur, the latter from Jagatsukh, two stages above Sultánpur. Since the coolies from these villages will go only on the one route it is necessary when both glaciers are to be visited to go from Jagatsukh. The same coolies remain with the traveller from Jagatsukh to Shigri and will, if desired, descend the left bank of the Chandra to Koksar. At this place other coolies are to be obtained for the visit to Sonápáni. Shigri is 3½ days' march from Jagatsukh, the route being *viâ* Chika, the Hamta, Chahtru and Putiruni. No habitations are to be met with after the traveller leaves Hamta village which is about 4 miles north of Jagatsukh. This necessitates taking food for the servants, and it is customary to obtain the supplies at Jagatsukh. The traveller will expedite his journey if he takes supplies from Sultánpur. The Chandra valley, especially between Chahtru and Shigri, is wild and desolate in the extreme, and wood is not to be obtained. For this reason care should be taken that an ample stock of charcoal is carried.

Supplies.

The slopes of the Chandra valley are very unstable, particularly so above Chahtru, and a look-out should be kept for falling stones. On the high bank overlooking the Chandra at Chahtru there is a small camping ground protected from stone-falls by several rocks. At Putiruni there is an excellent camping ground, and at Shigri, where the track rises to cross the shoulder of the hill, there is a small sheltered flat suitable for a camp.

Camping grounds.

Shigri is on the left bank of the Chandra, and Sonápáni on the right. The river is unfordable, so that it is necessary to descend to New Koksar and cross the bridge. The new rest-house at Koksar is a hard day's march from Chahtru. From New Koksar a road, which is a disused portion of the Kúlú-Lahaul trade route, runs for about 4 miles and ends at the ruined bridge and rest-house of Old Koksar. There is then a stiff climb of 3½ miles along the Sonápáni stream before the ice-cave is reached.

Route from Shigri to Sonapani.

Along the margin of the desiccated lake-bed there are several excellent camping places, and good clear water runs in abundance from the surrounding hills. Wood is scarce, but may be obtained from the banks of the Chandra above the old rest-house. Food supplies are to be bought in New Koksar, and in cases of difficulty with the lambardár it is advisable to communicate with the Thákur Sahib of Kyelung. Colonel Tyacke in his book, "The Sportsman's Manual," writes that the Sonápáni Nalá furnishes good sport.

Camping ground.

Supplies.

August is the best month in which to visit the glaciers for the purpose of making measurements. The passes are rarely open until May, and sometimes not until June. Snow may be expected about September 15th. Lahaul is considered a cloudless and rainless country.

Month most suitable for visit.

I.—THE SONAPANI GLACIER, CHANDRA VALLEY.

Probable origin of the name.

The word "Sonápáni" appears to mean "Golden-water." It is quite possible that the name has been given to this glacial stream, because in the lower portion of its course it runs over rocks which have a golden lustre. These rocks are micaceous schists, in which, on weathering, the mica (evidently a variety rich in iron) takes on a yellow-bronze lustre, probably due to schillerization. When wet these rocks gleam like golden pavements.

Height of glacier.

A good view of the glacier, desiccated glacier lake and old terminal moraine is obtained from the Rhotang Pass. The height of the pass is 13,500 feet, and the glacier is only slightly lower, so that its height may be taken at about 13,000 feet.

Position of glacier.

From the old rest-house of Koksar the glacier lies roughly N.N.E., and the ice-cave is distant about 3½ miles. The desiccated lake is 1½ miles long, so that from the terminal moraine which held up the lake (see Plate 60) there are two miles of glacier stream. This stream flows down a narrow valley and has cut through several moraines, which will be described later.

The glacier.

The end of the glacier is set in a circle of peaks which is broken to the N.N.E., and the ice stretches for 5 or 6 miles in that direction. Thus very little of the glacier is seen from the lake-bed (see Plates 40 and 41).

The snout of the glacier.

An ice-cliff forms the snout and it has a concave shape with the concavity pointing northwards. The stream issues from an ice-cave situated towards the western limb of the curved ice-cliff. To the south of the snout, and near to it, is a small terminal moraine. Just before our arrival at Sonápáni there had been three days of heavy snowfall, so that until near the time of our departure the glacier was hidden. When the snow on the lower portions disappeared the ice near the snout was seen to be entirely covered by stones. At this time there was a constant fall of boulders and small rocks from the ice-cliff on to the moraine at the foot.

The desiccated lake-bed.

A plain consisting of mud, fine sand, pebbles and angular gravel— very long in comparison with its width, and twisting as it follows the contours of the bounding slopes—is all that remains of what undoubtedly was a glacier lake. Along the length of the bed one main glacier stream runs at a good rate. In addition to this, many smaller branches meander and are augmented by the clear-water streams from the surrounding hills. As one would expect, the material forming the surface of the bed at the northern end is larger and more angular in character than that at the southern end. The lake-bed is bounded almost everywhere by large talus slopes, which, especially near the glacier, are very unstable.

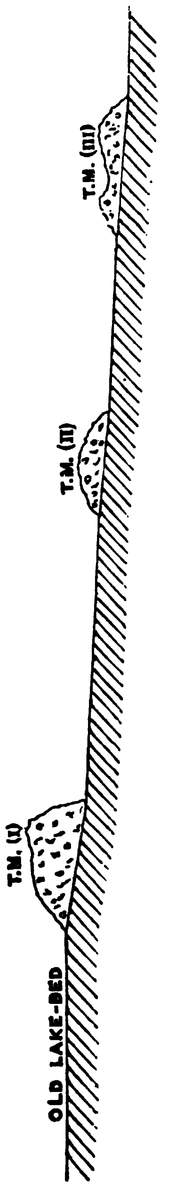


Fig. 1.—Diagrammatic Representation of Gradients in the Sonápáni Stream.

[T. M. indicates a terminal moraine.]

The lake moraine.

The waters of the old lake were held up by a large terminal moraine. The surface of the present gravel bed is on a level with the breach which is at the western end of the moraine.

Older terminal moraines.

Three more old terminal moraines are cut through by the Sonápáni stream after its escape from the lake-bed.

The accompanying woodcut (fig. 1) diagrammatically represents the gradients seen in the course of the stream. Through the moraines the gradients are steep, whilst between them they are much flatter, and all the gradients in the lower course of the stream are less than those in the higher parts. The lowest moraine is probably the oldest, since it is found clinging to the northern slope of the Chandra valley and within a short distance of the present Chandra river. The central portions of the moraine have been removed by the glacier stream and two long ridges, running away at right angles from the hill slopes and parallel to the stream, are all that now remain (see Plate 43).

Details of Photo. Stations.

Six stations from which to take photographs were selected (see sketch-map, Plate 60). Stations Nos. I, II and III, situated at the southern end of the lake-bed, were not marked, but bearings of prominent peaks were taken by a prismatic compass. Large rocks were selected for stations Nos. IV, V and VI. Marks were cut in the rocks and were then thickly painted red. Prismatic compass bearings to peaks were also taken. All the photographs taken have not been reproduced in this paper; but the negatives of those not reproduced, together with full details, are stored for reference in the office of the Geological Survey.

The photographs were taken with a Ross ordinary rapid rectilinear lens, the camera being horizontal in all cases.

Photo. Stations.

STATION.	Marks.	Direction of Camera.	BEARINGS OF PEAKS. (See Plates 40, 41, 42 and 43.) Peak A.	Peak B.	Peak C.	Peak D.	Peak E.
I	Unmarked.	N. 36° E.	N. 16° E.	N. 22° E.	E. 39° N.	...	...
II		N. 42° E.	N. 33° E.	N. 40° E.	E. 23° N.	...	...
III		N. 35° E.	N. 30° E.	N. E.	...	...	...
IV	⊕ Cut in rock and painted red.	N. 41° E.	N. 25° E.	N. 35°·5 E.	...	...	...
V	◁	E. 20° N.	...	N. 36° E.	E. 16° N.	...	...
VI	+	S. 30° W.	N. 28°·5 E.	N. 37° E.	E. 17° N.	S. 21°·5 W.	W. 42° S.

List of Plates.

II.—BARA SHIGRI, CHANDRA VALLEY.

This glacier, whose name signifies "boulder-covered ice," flows northwards and debouches into the Chandra river where the latter from a southerly course is deflected westwards, close to the Spiti border. It is mentioned in a book by J. Calvert, F.G.S., M.I.C.E., called " Kullu, the silver country and Vazeer-Rupi of the Vazeers," p. 60 (map inaccurate): the Gazetteer of the Kángra District, Vol. II, Part 3, contains a brief notice of the glacier and the surrounding country. An interesting description of the former with large photographs of the ice-cave are given in P. H. Egerton's "Journal of a Tour through Spiti (p. 11)."

The ice-cave is large and well-marked. Ice extends beyond this for a short distance on the left bank, which is formed by the precipitous talus-covered slope of a mountain-spur, and for a long distance on the right bank which is composed of ice and a vast area of moraine matter and talus (see Photographic Station No. IV, Plate 46). The ice on the right bank is exposed in several places as an ice-cliff, but the amount of moraine is so enormous on this side that it would be difficult to locate the boundary of the ice: from the shape of the moraine, ice probably extends at least as far as Photographic Station No. III (see map, Plate 61). Above the cave the ice is more or less completely covered by moraine and débris as far as can be seen from the cave or from the mass of moraine material below this. The upper part of the glacier is hidden from view by the above-mentioned mountain-spur round which the glacier curves.

There are no means of crossing the glacier stream which is everywhere and at all times of the day a roaring torrent. To reach the right bank of the stream the glacier must be crossed above the ice-cave.

Owing no doubt to the lateness of the upheaval in this region, and the consequent immaturity of the drainage system, the valleys are narrow and their enclosing ridges lofty and precipitous. Consequently the former are covered irregularly but very extensively with ordinary débris split off by heat, frost and rain, from the peaks above. This happens in the neighbourhood of glacier snouts as well as elsewhere, and it is frequently impossible to distinguish between true ice-borne moraine matter and ordinary débris fallen directly into the valley from the mountain sides. At the debouchement of the Shigri glacier, however, the Chandra valley is comparatively wide, and the greater number of the boulders covering it, with the exception of those near the base of the mountain slopes, no doubt represent true 'moraine.' Many of them shew distinct grooving and polishing, a rock face of true granite being made thereby to simulate gneiss. Well-rounded water-worn boulders are locally abundant, indicating former courses of the glacier stream.

At some considerable distance from the ice-cave, on the right bank of the stream, the ice which forms the core of the stream bank ends in a concave cliff, below which is a water-course with well rounded boulders, proceeding in the direction of the Chandra: this has evidently been a secondary 'ice-cave' or point of issue for water, though none could be seen flowing at the time.

Mr. Skemp, the Officiating Assistant Commissioner of Kúlú, informed us that, a mile or two northwards from the bend in the Chandra river, there is evidence of a lake having existed in the course of the river, in the form of a large sandy plain. This is said to have been formed by the damming up of the Chandra by the Shigri moraine, and is mentioned in Egerton's book[1] as existing seventy years ago. Colonel Tyacke[2] also records it. There is no doubt that the glacier did at one time extend much further than it does now: the vast size and extent of the terminal moraine is sufficient to prove this. The ¼ inch Frontier map published in 1874 shews the Shigri stream

[1] Journal of a Tour through Spiti by P. H. Egerton, D. C. of Kangra.

[2] Page 52, Sportman's Manual in Kullu. Colonel Tyacke.

running straight into the Chandra river immediately opposite where the glacier should be[1]: now however the junction is about two miles further down the river. This appears to be due to the retreat of the ice until it was possible for the stream to find its way round the back of the terminal moraine and so join the Chandra farther down. From Egerton's photographs taken in July 1863, the mountains behind the glacier snout appear to be closer than they do in the plates published in this paper, but distances in photographs are deceptive when the latter are taken from different places, and with different lenses. Although the termination of the glacier is so concealed by the vast quantity of boulders, there is no evidence of the latter having been pushed forward by the ice.

Details of Photographs.

The only places suitable for photographic stations were large boulders in the vast field of moraine matter lying around the glacier termination. The only rock *in situ* near the glacier snout was the mountain spur the base of whose steep talus-covered slope is seen in Plate 44, and this was unsuitable for a photographic station on account of constantly falling dèbris, difficult accessibility, and inconvenient position.

Photographic Station I (*Plate 44*).—An enormous granite boulder on the edge of the left bank of the glacier stream, close to ice-cave—at the time of our visit by far the largest boulder in the neighbourhood. The upper surface was marked with chisels and vermilion paint thus :—

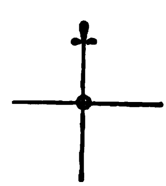


FIG. 2.

The bearings of three peaks (lettered in the plates), taken with a prismatic compass, from this mark on the boulder were :—

Peak A	83° E. of N.
Peak B	65° E. of S.
Peak C	41° E. of S.

[1] The glacier is not recorded on this map.

Direction in which levelled camera pointed . .	70° E. of S.
Lens	Ross' wide angle —6 inches.[1]
View	Ice-cave, glacier stream, and peaks: the upper part of the glacier lies between Peak C and the talus-covered slope in the foreground to the right of the picture. The cliffs of ice shew "dirt-bands."

Photographic Station III[2] (*Plate 45*).—A large gneiss boulder towards the margin of the moraine and some distance from the ice-cave. As the boulder would probably move, it was not marked: its *bearings* are—

Peak B	63° E. of S.
Peak C	39° E. of S.
A low spur on the opposite side of the Chandra river	43° E. of N.
Direction in which camera pointed	49° E. of S.
Lens	Ross' wide angle.
View	Ice-cave, slope forming left bank, and moraine with ice shewing here and there. Ice probably extends as far as or close to this station.

Photographic Station IV (*Plate 46*).—

Direction in which camera pointed	43° E. of S.
Lens	Ordinary rapid rectilinear.
View	Ice-cave, mountain slope forming left bank, and peaks.

PERAD GLACIER.

An attempt was made to survey this, but had to be abandoned on account of continued snow. The glacier is very accessible, being within half a mile of the camping ground of Putiruni, and, although small, would be eminently suitable for the purpose under consideration. There is a well-marked ice-cave which could be photographed from accessible rock *in situ*. The glacier stream runs between two large lateral moraines, and is bridged by planks. Snow is to be expected here and at Shigri after the 15th September, and any examination of these glaciers should precede this date.

[1] A second similar photograph (not reproduced) was taken with an ordinary rapid rectilinear lens.

[2] Photos from *Station* II not reproduced.

C.—NOTES ON CERTAIN GLACIERS IN KUMAON. BY G. DEP. COTTER, B.A., F.G.S., AND J. COGGIN BROWN, B.SC., F.G.S. (With Plates 47 to 59, 62 to 65.)

INTRODUCTION.

OUR visit to the glaciers of Kumaon took place in the summer of 1906, when four of the largest and most easily accessible glaciers were examined, *viz.*, the Pindari (Lat. 30° 15½′; Long. 80° 2′), the Milam (Lat. 30° 27′; Long. 80° 10′), the Shankalpa (Lat. 30° 19½′; Long. 80° 21½′), and the Poting (Lat. 30° 12½′; Long. 80° 12′).[1] Of these the Pindari is the best known, being a favourite tourist resort, and approachable by an excellent road with staging bungalows to Phurkia, four miles from the glacier. The route to the Pindari glacier leads from Ranikhet or Almora, through Bagesar and Kápkot, (near the latter of which villages the road to Milam diverges eastward) and is seven days' journey from Almora by easy marches.

To visit the remaining three glaciers, it is necessary to take small tents. The best route to Milam leads from Kápkot through the villages of Sáma, Tejam, Girgaon, Munsyari, and the camping grounds of Lilam, Bugdiar, Rilkot, and Burphu. The village of Milam is one mile distant from the Milam glacier, and is about eleven days' march from Almora. The road is suitable for ponies as far as Munsyari; beyond this village however the remaining thirty miles along the valley of the Gori Gunga to Milam must be traversed on foot, as the steepness of the ascent has made it necessary to build the road in the form of a staircase in many places.

The Poting glacier is about six miles distant from Bugdiar, and is reached by an easy hill-path leading through some of the most beautiful scenery of Kumaon. To reach the Shankalpa glacier, it is wiser to take the hill road from Rilkot over a ridge about 15,500 feet high north of Haseling peak, and from whence a fine view of Nanda Devi can be obtained, rather than to travel from Lilam up the valley of the Rálam river, as the latter route is difficult for coolies with burdens, and is impossible for baggage animals. By the former route Rálam

[1] See Atlas of India, Quarter-Sheet, 66 N. E.

village, which is 2½ miles from the Shankalpa glacier, may be reached in two days' march from Rilkot.

The country north of Munsyari is inhabited by the Bhotias, a pastoral people of Mongolian affinities, who still retain their nomadic habits. In June they move north to Milam and the neighbouring villages from Munsyari and Tejam, to which places they again return southwards in the latter half of September owing to the advance of the winter snow. It would therefore be a matter of great difficulty to reach the glaciers at any other time than from the months of June to September; and indeed a visit made at another time of year would be of little service to those who wish to study the glaciers of these parts as the country is more or less covered with snow. Owing to the exceptional lateness of the fall of the winter snow in 1906, we were enabled to visit the Poting glacier in October, but at that time the country had been already deserted by the Bhotias, and the snow was beginning to fall at the time of our visit.

The altitudes of the snouts of these four glaciers average nearly 12,000 feet. At Martoli camping ground near the Pindari glacier, the elevation is 11,720 feet; while at the snout of the Milam glacier it is 11,340 feet. The elevations at the snouts of the other two glaciers had to be guessed by aneroid, and were judged to be roughly 12,000 feet. The Bhotia shepherds all agree in the opinion that the glaciers are in retreat. In no case did we fail to find numerous terminal moraines in front of the ice-caves, indicating a retreat at some past period: and from local information there is reason to believe that this retreat is still going on.

In conclusion, it is worth remarking that the scenery along the road to Milam from Girgaon onwards would well repay visitors for the inconvenience of tent-marching in the monsoon. The savage precipices and luxuriant vegetation of the Gori Gunga valley between Munsyari and Bugdiar form a picture not easily forgotten; and it seems a pity that the more popular and easy, but somewhat tamer route to the Pindari glacier has drawn away the attention of visitors from this fascinating valley.

I.—THE PINDARI GLACIER.

(BY G. DEP. COTTER.)

The following paper and sketch-map is based upon observations made during my visit to the glacier in July, 1906.

General description.

The glacier is fed by two ice-flows, the larger originating from névés on the slopes of 22,530 feet peak called locally Nanda-Kot; and the other descending in a cascade from between 20,740 feet peak (Banghattia) and an unnamed peak, 21,624 feet in height, wrongly identified with Nanda Devi by the Bhotias of the vicinity. These two flows are separated by a medial moraine which terminates about a mile from the ice-cave. Of the lateral moraines flanking the glacier, that to the left or S.E. is in comparatively open ground, while that to the N.W. (the right lateral moraine) is pressed close against the cliff-wall, and is therefore imperfectly developed. Surface moraine is seen both on the lower glacier and on the flow which descends from Nanda-Kot, but the smaller cascade is of clear ice (see Plate 51).

Crevasses appear to be of less frequent occurrence here than in the case of the other three glaciers of Kumaon included in this paper; possibly this may be due to a slower rate of movement of the glacier-ice. General Strachey, who examined the glacier in May, 1847, in an interesting paper upon the Pindari and Kuphini glaciers (*Journal, Asiatic Society, Bengal,* Vol. XVI, 2, page 203), gives the following theodolite-observations, showing the rate of movement of the glacier-ice :—

	MEAN MOTION OF ICE IN 24 HOURS (IN INCHES).	
	At lateral moraine.	On middle of glacier.
Lower part of glacier	4·8	9·4
Upper part of glacier . . .	5·3	10·0

These results, compared with the calculations given by Professor Tyndall of the rate of motion of the Mer-de-Glâce (Glaciers of the Alps, page 275), lead us to suppose that the motion of the Pindari glacier is, comparatively, very slow.

Terminal moraines.

Recent terminal moraines are very small and imperfectly developed, and are situated close to the glacier-snout. Ancient grass-grown moraines occur in the Pindari valley near Martoli, about 1½ miles from the glacier (see Plate 47).

The old grass-grown moraines marked on the sketch-map (Plate 62) appear to be lateral from their position.

Secular movement of glacier.

The villagers of the neighbourhood say that the glacier is in retreat, but cannot give any exact data. Colonel J. W. A. Mitchell, writing in 1894, says "the glacier appears to have retreated about 100 yards since I visited it in 1884."[1]

Ice-cave and measurements from four fixed points.

The ice-cliff above the ice-cave of this glacier is very small, as compared with those of the Milam, Poting, and Shankalpa glaciers (see Plate 48). At Shankalpa the ice-cave together with the ice-cliff above is about 300 feet in height, while at Pindari the ice-cave and cliff is roughly about 40 feet.

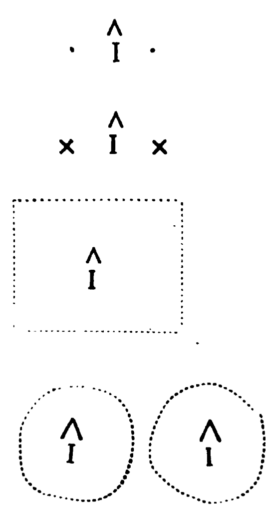
The four fixed points, indicated on the map as A, B, C, D, forming Plate 62 have been marked in the field by arrows cut in the rock thus :—

A is marked........................

B is marked... ....

C is marked................ ......

D is marked........................



These marks were afterwards paintedred; the dotted lines indicate that the rock has been painted, but not chiselled.

It would be convenient for visitors to the glacier to calculate its secular movement by reference to the sketch-map forming Plate 62, which is on a sufficiently large scale to determine a change of 20 or 30

[1] This remark is quoted from a book kept in the Phurkia dâk bungalow for the purpose of recording observations upon the movement of the glacier.

feet. Photographs were taken from stations C (Plate 49) and D (Plate 50) showing the position of the glacier; and it would be useful for visitors in estimating the secular change, to take similar photographs from these points. I have also made measurements to a cairn built over the ice-cave, from the four fixed points. This cairn was 77 feet distant in a direction 340° E. of N. from the centre of the ice-cave.

Wherever measurement was made on sloping ground the horizontal distance was calculated by taking the angle of slope; and the same method has been adopted in taking the measurements of the remaining glaciers of Kumaon, described in this paper.

Horizontal distance from A to cairn over ice-cave	.	2,027 feet.
„ „ „ B „ „ „	.	2,571 „
„ „ „ C „ „ „	.	1,155 „
„ „ „ D „ „ „	.	1,023 „

The stations may be distinguished by reference to the map (Plate 62), and by the following characters:—A is a grey schistose boulder; B is a small cliff of grey schistose rock, the top of which is grass-grown; C is a white boulder lying on the ridge of the right lateral moraine; D is a cliff similar to B.

List of Plates of the Pindari Glacier.

PLATE 47.—Old grass-grown moraines near Martoli camping ground.

PLATE 48.—Pindari glacier; ice-cave, right and left views.

PLATE 49.—View of Pindari glacier from C, showing snout.

PLATE 50.—View of Pindari glacier from D, showing right and left lateral moraine with glacier between.

PLATE 51.—View of Pindari glacier from D, showing the upper glacier, with medial moraine and the two ice-flows.

PLATE 52.—Plane-table sketch-map of the snout of the Pindari glacier, as it was in July, 1906.

II.—THE MILAM GLACIER.

(BY G. DEP. COTTER AND J. COGGIN BROWN.)

This glacier was visited in August, 1906, when the accompanying photographs (Plates 52 to 55) and sketch-map (Plate 63) were made.

General remarks.

The earliest mention of this glacier, which we are able to find, is in a journal by Captain Hodgson, describing a visit to the sources of the Ganges in the year 1817 (*Asiatic Researches*, No. XIV, Qu., pages 117-128). He says:—

"The . . . Ganges issues from under a very low arch at the foot of a grand snow-bed . . . . . over the debouche, the mass of snow is perfectly perpendicular, and from the bed of the stream to the summit we estimate the thickness at little less than three hundred feet of solid frozen snow, probably the accumulation of ages; it is in layers of some feet thick, each seemingly the remains of a fall of a separate year. . . . . Many rents in the snow appear to have been recently made, their sides shrinking and falling in. . . . . . Ponds of water form in the bottoms of these."

This glacier, being about 12 miles in length, is the second in size of the glaciers of Kumaon, and is formed by the junction of nine large tributary glaciers. It fills practically the whole valley, so that the lateral moraines are in many places indistinguishable from the scree of the hill-sides. Terminal moraines are numerous, and tend to run in low ridges parallel to the glacier front. The ice-cliff above the cave sweeps in a huge horse-shoe curve, and the moraine-talus, which covers the ice of the glacier-snout, grades imperceptibly into terminal and lateral moraines. We were unable to fix the precise limit of the extension of the ice.

Amongst the morainal débris, fossiliferous rocks are rare; schist is common, and occasionally contains malachite. The most common rock is red Haimanta sandstone; the conglomerate is rare. Scratched boulders are of common occurrence at this glacier, the scratches crossing one another at all angles. The boulders also often show polishing. We have marked on the map the places where such boulders are most numerous. We saw no traces of glaciation of the rock walls of the valley-sides, since they are hidden by scree. Glaciers-tables are found on the clearer ice some distance up the glacier. On the lower part of the glacier, numerous transverse crevasses can be seen.

Secular movement of the glacier.

There is a tradition amongst the Bhotias, that the glacier about 1,000 years ago extended to Milam village, one mile distant. That it extended at least to Bilju village south of Milam is shown by the old moraines which lie to the E. of the Gori Gunga river (see Plate 52). According to Rai Kishen Singh Bahadur of Milam, well known to science as "A. K.," the explorer of Tibet, the ice-cave fifty-seven years ago was about 800 yards in advance of its present position.

The successive ridges of the lateral moraines, which can be observed in the photographs (Plates 53 and 55) and the map (Plate 63) seem to indicate that there have, possibly, been several periods of maximum rate of retreat, divided by intervals of comparative quiet.

Photographs and observations from fixed points to ice-cave.

Three points, A, B, and C, were chosen, and their positions marked on the map (Plate 63). A to the S.E. of the ice-cave, high up on the top of the left lateral moraine, is marked by an arrow chiselled in a large boulder, and smeared with red paint; B is situated in the low ground near the river, in front of the glacier, and is marked by a cairn, on the topmost stone of which an arrow is cut; C is also marked by an arrow cut in the rock of the valley wall. From each of these three fixed points photographs (Plates 53 to 55) of the ice-cave have been taken. The following bearings from A and C to a cairn built over the centre of the cliff of the ice-cave, taken with the prismatic compass, may be found useful in the determination by subsequent visitors of the change of position of the ice-cave:—

From A to cairn	$295\frac{1}{8}°$ E. of N.
From C to cairn	$83\frac{3}{8}°$ E. of N.

We have requested Rai Kishen Singh Bahadur of Milam to see that the cairn erected at station B is preserved from dilapidation from year to year.

List of Plates of the Milam Glacier.

PLATE 52.—The valley leading to the Utardhura Pass blocked up by moraine from the Milam glacier. Taken from Milam.

PLATE 53.—Milam glacier and ice-cave from A.

PLATE 54.—Milam glacier and ice-cave from B.

PLATE 55.—Milam glacier and ice-cave from C.

PLATE 63.—Plane-table sketch-map of the snout of the Milam glacier, as it was in August, 1906.

III.—THE SHANKALPA GLACIER.

(BY G. DEP. COTTER AND J. COGGIN BROWN.)

We visited this glacier at the end of September, 1906. The Rálam valley, in which this glacier lies, becomes a narrow cañon near its junction with the Gori Gunga valley, and owing to the difficulties of the road through this gorge, travellers usually use the road from Rilkot or Burphu over the Haseling ridge. The Bhotias, who are the only inhabitants of this part of the Himalayas, move south at the end of September to Munsyari and Tejam; and as a rule, from October to March, all the villages in the Gori and Râlam valleys north of Lilam are deserted for the winter, the country being covered with snow.

General description.

The Shankalpa glacier is formed by the union of two tributary glaciers, the Kálá Buland, and the Therchet. The surface of the glacier is much cut up by crevasses, both longitudinal and transverse; and to walk upon it is often difficult. The snout of the glacier, as can be seen from the map, has now reached a spot where the valley suddenly narrows. The ice-cliff above the cave is pressed close against a large rock, possibly a landslip from the S.E. valley-wall. It will be seen from the map, forming Plate 64, that the lateral moraines extend only 800 yards in front of the glacier. We found no evidence (such as old grassy moraines) to show that the glacier had ever advanced further down the valley than the limit of the present lateral moraines.

The Bhotias, who inhabit Râlam village close to this glacier, are a branch of the Dhárma valley stock, and are a simple pastoral folk, while their neighbours of Milam have in part adopted Hindu customs. From them we learned that the glacier twenty-five years ago occupied a position about 700 feet in advance of the present terminus. According to the Bhotia shepherds, the terminal moraine, which lies on the N.W. side of the river and between the two streamlets (see map, Plate 64), was then the boundary of the ice. It therefore seems probable that the glacier is in retreat.

Glaciation.

The cliff on which the N.W. side of the ice-cave touches and also the cliff on which station A is marked exhibit striæ and polished surfaces in a manner unmistakably glacial. We found rock-surfaces similarly polished on the N.W. valley-wall about one mile up the glacier. In addition to this, scratched boulders occur here as at the Milam glacier, but we saw them only on the S.E. side of the river.

Surface moraine.

Many fossiliferous rock-fragments are found upon the surface moraine of the glacier; we have also seen specimens containing traces of azurite; especially interesting is the occurrence of orpiment about one mile up the glacier; this has been already mentioned in these *Records* (Vol. XXXV, Part I, page 28).

Ice-cave:—measurements and photographs from fixed points.

Of the three fixed points selected at this glacier, A and C are marked by arrows cut in the rock of the valley-walls, and smeared with red paint; B is similarly marked on a large boulder close to the river bank. For the purpose of measurement a cairn was built over the ice-cave (see Plate 64) and measurements were obtained from the three fixed points. The following are the horizontal distances from the fixed points to the cairn:—

From A	468 feet.
From B	1,106 „
From C	1,370 „

Photographs of the glacier from A and B are reproduced in Plates 56 and 57.

List of Plates of the Shankalpa Glacier.

PLATE 56.—Shankalpa glacier and ice-cave from A, showing glaciated rock.

PLATE 57.—Shankalpa glacier and ice-cave from B.

PLATE 64.—Plane-table sketch-map of the snout of the Shankalpa glacier, as it was in September, 1906.

IV.—POTING GLACIER.

(BY G. DEP. COTTER AND J. COGGIN BROWN.)

The Poting glacier, being one of the more southerly of the glaciers of Kumaon, and situated as it is in the gneissic zone of the Himalayas, is surrounded by perhaps the most beautiful scenery in this district. The valley in which the glacier lies, from the glacier-snout to where it joins the valley of the Gori Gunga at Bugdiar, is clad with pines, and the more level parts are densely wooded with juniper, birch, rhododendron, and the Himalayan rowan or mountain-ash. The hardness of the gneissic rocks gives rise to narrow gorges, and streams, which near Milam and Rálam have cut out valleys in the hill-sides, and here descend in waterfalls. Our visit to this glacier was in October, 1906.

General description.

The glacier is formed from névés on the slopes of Nanda-Kot (22,530 feet peak). As waterfalls characterise this area, so also the ice flows in a cascade from the shoulder of Nanda-Kot to form the lower glacier. While the three glaciers already described all lie at a low level between their lateral moraines, the Poting is, at a short distance above the ice-cave, level with the ridges of its laterals. These laterals are separated from the valley-walls by open ground. Terminal moraines in front of the glacier appear to be not recent. Many of the boulders which strew the floor of the valley are metamorphosed schists, into which has been intruded a network of tourmaline-granite veins; the schists often contain abundant blue crystals of kyanite.

Diurnal movement of glacier.

We were unable to make accurate measurements of the diurnal flow of the ice, since we had not brought a theodolite; four flagstaffs were however placed in a line upon the glacier. After eight days two of the flagstaffs in the centre of the glacier appeared to have moved slightly in advance of the rest (not more than six, and probably nearer to three inches in advance). The remaining flagstaffs appeared not to have moved. It must be remembered that at this time of year the daily movement of the ice would be approaching its minimum value.

Measurements to the ice-cave from fixed points.

A cairn was made over the ice-cave (see Plate 65) and measurements taken from three fixed points, A, B, C, all marked by arrows cut in the rock and painted red. The measurements are as follows:—

From A to cairn, horizontal distance	. .	1,405 feet.
From B " " "	. .	949 "
From C " " "	. .	500 "

Photographs, reproduced as Plates 58 and 59, show in one case a general view of the glacier, and in the other a view from station C.

List of Plates of the Poting Glacier.

PLATE 58.—Poting glacier and ice-cave with snowy ranges in the background. Taken from camping-ground.

PLATE 59.— Snout of the Poting glacier from C.

PLATE 65.—Plane-table sketch-map of the snout of the Poting glacier, as it was in October, 1906.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA.

VOL. I, 1868.

Part 1.—Annual report for 1867. Coal-seams of Tawa valley. Coal in Garrow Hills. Copper in Bundelkund. Meteorites.

Part 2.—Coal-seams of neighbourhood of Chanda. Coal near Nagpur. Geological notes on Surat collectorate. Cephalopodous fauna of South Indian cretaceous deposits. Lead in Raipur district. Coal in Eastern Hemisphere. Meteorites.

Part 3.—Gastropodous fauna of South Indian cretaceous deposits. Notes on route from Poona to Nagpur *viâ* Ahmednuggur, Jalna, Loonar, Yeotmahal, Mangali, and Hinganghat. Agate-flake in pliocene (?) deposits of Upper Godavery. Boundary of Vindhyan series in Rajputana. Meteorites.

VOL. II, 1869.

Part 1 (out of print).—Valley of Poorna river, West Berar. Kuddapah and Kurnool formations. Geological sketch of Shillong plateau. Gold in Singbhoom, etc. Wells at Hazareebagh. Meteorites.

Part 2.—Annual report for 1868. Pangshura tecta and other species of Chelonia from newer tertiary deposits of Nerbudda valley. Metamorphic rocks of Bengal.

Part 3.—Geology of Kuch, Western India. Geology and physical geography of Nicobar Islands.

Part 4.—Beds containing silicified wood in Eastern Prome, British Burma. Mineralogical statistics of Kumaon division. Coal-field near Chanda. Lead in Raipur district. Meteorites.

VOL. III, 1870.

Part 1.—Annual report for 1869. Geology of neighbourhood of Madras. Alluvial deposits of Irrawadi, contrasted with those of Ganges.

Part 2 (out of print).—Geology of Gwalior and vicinity. Slates at Chiteli, Kumaon. Lead vein near Chicholi, Raipur district. Wardha river coal-fields, Berar and Central Provinces. Coal at Karba in Bilaspur district.

Part 3 (out of print).—Mohpani coal-field. Lead-ore at Slimanabad, Jabalpur district. Coal east of Chhatisgarh between Bilaspur and Ranchi. Petroleum in Burma. Petroleum locality of Sudkal, near Futtijung, west of Rawalpindi. Argentiferous galena and copper in Manbhum. Assays of iron ores.

Part 4 (out of print).—Geology of Mount Tilla, Punjab. Copper deposits of Dalbhum and Singbhum: 1.—Copper mines of Singbhum: 2.—Copper of Dalbhum and Singbhum. Meteorites.

VOL. IV, 1871.

Part 1.—Annual report for 1870. Alleged discovery of coal near Gooty, and of indications of coal in Cuddapah district. Mineral statistics of Kumaon division.

Part 2.—Axial group in Western Prome. Geological structure of Southern Konkan. Supposed occurrence of native antimony in the Straits Settlements. Deposit in boilers of steam-engines at Raniganj. Plant-bearing sandstones of Godavari valley, on southern extensions of Kamthi group to neighbourhood of Ellore and Rajamandri, and on possible occurrence of coal in same direction.

Part 3.—Borings for coal in Godavari valley near Dumagudem and Bhadrachalam. Narbada coal-basin. Geology of Central Provinces. Plant-bearing sandstones of Godavari valley.

Part 4.—Ammonite fauna of Kutch. Raigur and Hengir (Gangpur) Coal-field. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.

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Vol. V, 1872.

Part 1.—Annual report for 1871. Relations of rocks near Murree (Mari), Punjab. Mineralogical notes on gneiss of South Mirzapur and adjoining country. Sandstones in neighbourhood of first barrier on Godavari, and in country between Godavari and Ellore.

Part 2.—Coasts of Baluchistan and Persia from Karachi to head of Persian Gulf, and some of Gulf Islands. Parts of Kummummet and Hanamconda districts in Nizam's Dominions. Geology of Orissa. New coal-field in south-eastern Hyderabad (Deccan) territory.

Part 3.—Maskat and Massandim on east coast of Arabia. Example of local jointing. Axial group of Western Prome. Geology of Bombay Presidency.

Part 4.—Coal in northern region of Satpura basin. Evidence afforded by raised oyster banks on coasts of India, in estimating amount of elevation indicated thereby. Possible field of coal-measures in Godavari district, Madras Presidency. Lamets or infra-trappean formation of Central India. Petroleum localities in Pegu. Supposed eozoonal limestone of Yellam Bile.

Vol. VI, 1873.

Part 1.—Annual report for 1872. Geology of North-West Provinces.

Part 2.—Bisrampur coal-field. Mineralogical notes on gneiss of South Mirzapur and adjoining country.

Part 3.—Celt in ossiferous deposits of Narbada valley (Pliocene of Falconer): on age of deposits, and on associated shells. Barakars (coal-measures) in Beddadanole field, Godavari district. Geology of parts of Upper Punjab. Coal in India. Salt-springs of Pegu.

Part 4.—Iron deposits of Chanda (Central Provinces). Barren Islands and Narkondam. Metalliferous resources of British Burma.

Vol. VII, 1874.

Part 1 (out of print).—Annual report for 1873. Hill ranges between Indus valley in Ladak and Shah-i-Dula on frontier of Yarkand territory. Iron ores of Kumaon. Raw materials for iron-smelting in Raniganj field. Elastic sandstone, or so-called Itacolumyte. Geological notes on part of Northern Hazaribagh.

Part 2.—Geological notes on route traversed by Yarkand Embassy from Shah-i-Dula to Yarkand and Kashgar. Jade in Karakas valley, Turkistan. Notes from Eastern Himalaya. Petroleum in Assam. Coal in Garo Hills. Copper in Narbada valley. Potash-salt from East India. On Geology of neighbourhood of Mari hill station in Punjab.

Part 3.—Geological observations made on a visit to Chaderkul, Thian Shan range. Former extension of glaciers within Kangra district. Building and ornamental stones of India. Materials for iron manufacture in Raniganj coal-field. Manganese-ore in Wardha coal-field.

Part 4 (out of print).—Auriferous rocks of Dhambal hills, Dharwar district. Antiquity of human race in India. Coal recently discovered in country of Luni Pathans, south-east corner of Afghanistan. Progress of geological investigation in Godavari district, Madras Presidency. Subsidiary materials for artificial fuel.

Vol. VIII, 1875.

Part 1.—Annual report for 1874. The Altum-Artush considered from geological point of view. Evidences of 'ground-ice' in tropical India, during Talchir period. Trials of Raniganj fire-bricks.

Part 2 (out of print).—Gold-fields of south-east Wynaad, Madras Presidency. Geological notes on Khareean hills in Upper Punjab. Water-bearing strata of Surat district. Geology of Scindia's territories.

Part 3.—Shahpur coal-field, with notice of coal explorations in Narbada region. Coal recently found near Moflong, Khasia Hills.

Part 4 (out of print).—Geology of Nepal. Raigarh and Hingir coal-fields.

Vol. IX, 1876.

Part 1 (out of print).—Annual report for 1875. Geology of Sind.

Part 2.—Retirement of Dr. Oldham. Age of some fossil floras in India. Cranium of Stegodon Ganesa, with notes on sub-genus and allied forms. Sub-Himalayan series in Jamu (Jammoo) Hills.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1907. [July.

A PRELIMINARY SURVEY OF CERTAIN GLACIERS IN THE NORTH-WEST HIMALAYA. BY OFFICERS OF THE *Geological Survey of India.*

CONTENTS.

INTRODUCTION. BY T. H. HOLLAND, *Director.*

Himalayan glaciers.

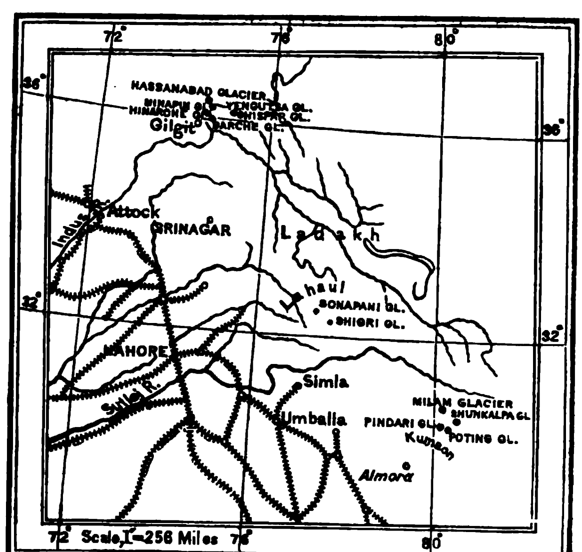
IN 1905, Mr. D. W. Freshfield, on behalf of the *Commission International des Glaciers*, drew the attention of Lieutenant-Colonel S. G. Burrard, F.R.S., Superintendent of Trigonometrical Surveys, to the importance of recording data for determining the secular movements of the principal Himálayan glaciers. As the work required the co-operation of all officers and private travellers likely to visit the glacier regions of the Himálaya, Colonel Burrard referred the question to the Board of Scientific Advice, and, on the recommendation of a sub-committee composed of Colonel F. B. Longe, R.E., Surveyor-General, Dr. G. T. Walker, F.R.S., and myself, the Board agreed on a system of observations, recommending that the distribution of the necessary information and collection of data should be under the control of the Geological Survey Department. The proposals having received the sanction of the Government of India, the first step in the investigation was taken by the deputation of five Geological Survey officers during August and September to make a preliminary survey of the principal glaciers in the Kumaon, Lahaul, and Kashmir regions.

Altogether twelve glaciers were examined, as follows:—

Kashmir Region.—The Barche (lat. 36° 3′, long. 74° 42′) and Hinarche glaciers (36° 5′, 74° 36′) in the Bagrot valley which leaves the Gilgit R. at lat. 35° 52′, long. 74° 31′; the Minapin (36° 13′, 74° 40′), Hispar (36° 7′, 75° 15′), and Yengutsa (36° 9′, 75° 4′) glaciers in the Nagir State, and the Hassanabad glacier (36° 18′, 74° 37′) in Hunza. These six were surveyed by Mr. H. H. Hayden.

Lahaul.—The Bara Shigri (32° 16′, 77° 39′) and Sonapani (32° 25′, 77° 25′) glaciers were examined by Messrs. H. Walker and E. H. Pascoe.

Kumaon.—The Pindari (30° 15½′, 80° 2′), Milam (30° 27′, 80° 10′), Shan Kulpa (30° 19½′, 80° 2½′), and Poting (30° 12½′, 80° 12′) glaciers were surveyed by Messrs. G. deP. Cotter and J. C. Brown.



The above sketch-map shows the positions of these twelve glaciers with reference to better-known parts of Upper India. In all cases plane-table sketches were made, showing the exact positions of the ice-caves with reference to points cut and painted on rocks in the valley as well as with prominent and unmistakable peaks in the vicinity. In some cases cairns were built over the marks, and in the Kashmir area these were placed in charge of the nearest village headmen. The cairn built near the Milam glacier was placed in charge of Rai Bahadur Kishen Singh, who is well known to science as "A.-K."

Photographs were taken from various points of view carefully marked on the map and described in the report, showing the state of the glaciers and the principal masses of moraine material at the time of the visit. These photographs will enable subsequent travellers to form an idea of any changes that may have occurred in the interval, and will thus make the observations of value even if the fixed points cut in the rocks are destroyed by weathering or by being overwhelmed with loose material.

The reports are issued in two parts, the first, dealing with the Kashmir region by Mr. Hayden, is published in this part of this volume, while the descriptions and illustrations of the Lahaul and Kumaon areas are issued with Part 4.

The short time available rendered it necessary that observations should be confined to one aspect of the glaciers, namely, that of their secular advance or retreat. It was impossible, under the circumstances, to make more than passing observations on such questions as the rate of flow, the lamination of the ice, included dirt bands, and erosive action. These interesting questions must be left for future workers, as it was important in as many instances as possible to fix at once, for the purposes of the main problem, the positions of the snouts and general disposition of the ice with regard to fixed features in the ground around.

The first point that strikes one on examination of the reports is the fact that the glaciers of the Hunza valley and the Karakoram range generally descend to lower altitudes than in the Lahaul and Kumaon regions. In the former region the snouts of the glaciers proceed down to levels of 7,000 or 8,000 feet, while in the latter region they melt before descending below the level of about 11,000 feet. In the Hunza region, also, there are two classes of glaciers—

(*a*) those which flow transversely to the trend of the mountain range, and are relatively short, with a steep descent reaching down to elevations as low as 8,000 feet and under; and (*b*) those which lie in troughs parallel to the range, and also approximately parallel to the strike of the rocks of which the range is composed. These, having at their angles of slope a less rapid fall, rarely descend below 10,000 feet, and form long glaciers, in some cases making the most magnificent ice-flows in the Himalayas; the Hispar glacier is some 25 miles in length, while the Biafo, which commences on the opposite side of the same col, is even longer, being as much as 39 miles in length.

The second point most prominently displayed is the evidence of general retreat shown by the occurrence in nearly all cases of old moraines (sometimes grass-covered) at lower levels in the valleys. This point does not, of course, necessarily mean that the glaciers are now in retreat, and two well-authenticated cases of recent advance have been found in the Yengutsa and Hassanabad glaciers. The valleys below the glaciers being generally covered by moraine material and talus from the hills around, very seldom reveal the solid rock, and consequently the evidence with regard to the erosive action of the ice is very unsatisfactory. Only two instances have been recorded of the solid basement rock being exposed and showing marks of glaciation, namely, the Shunkulpa glacier in Kumaon, and the Minapin glacier in Nagir. These observations are insufficient to show whether the glaciers had eroded material in large quantity, or had only succeeded in striating and polishing the rocks over which they flowed. In the case of the Minapin glacier, the rock striated is a crystalline limestone, over which the glacier must have formed a considerable ice-fall, the rounded mass of rock being striated on the lee-side as well as above.

One of the most interesting features recorded in the reports is the occurrence of a large, dry lake-basin, about 1½ miles in length and nearly a mile in width, immediately below the Sonapani glacier. This was formed by the damming up of the glacier stream by an old terminal moraine. The waters of the lake have, since the silting of the basin, cut through the moraine barrier and escaped, leaving a desiccated plain along which meander numerous branches of the glacier stream.

A.—NOTES ON CERTAIN GLACIERS[1] IN NORTH-WEST KASHMIR. BY H. H. HAYDEN, B.A., B.E., F.G.S. (With Plates 17—39.)

BAGROT.

Hinarche Glacier.

THE Hinarche glacier, which occupies the upper reaches of the main valley, rises in the snow-fields of the south-eastern slopes of Rakipushi (25,550 feet) and the high snowy range running thence eastward and separating Bagrot from Nagir. The sources of the glacier have not been mapped in detail, nor so far as I am aware have they been visited by any European, and its total length is consequently unknown. For about eight miles up from its snout it was mapped in 1892 by Sir Martin Conway, whose description of the glacier enables us to form some idea of the changes that have taken place in the interval that has elapsed since the date of his visit.

Near its snout, the glacier separates into two branches, the larger occupying the centre of the main valley, and the smaller turning obliquely towards Sat in the tributary valley on the east. These are separated by an old, partially pine-clad moraine, and an extensive terminal moraine over-grown with scrub surrounds the snout of the smaller branch.

The main branch as will be seen from the sketch-map (Pl. 33) is very much the larger of the two, and on its left front impinges against the precipitous slopes of the Gasunar ridge; here the path from Sat to Chira is forced first up over the ice and then along the face of the

[1] These glaciers are conveniently approached from Srinagar as starting point. From this city it is necessary to march to Gilgit *viâ* Tragbal, Astor and Bunji. From Gilgit the Minapin glacier is reached in three marches, by way of Nomal and Chalt. The march to the Hispar glacier is *viâ* Askurdás, Nagir and Huru; and from this camp the Darapu glacier can be examined. On returning to Huru the Hassanabad glacier is approached *viâ* Baltit (Hunza) and Aliábad. In order to survey the Barche ("Burche") and Hinarche glaciers it is necessary to return to Gilgit and march *viâ* Sinakar to Dar.

cliffs, till beyond the ice-cave it descends again to the broad valley below the glacier (see Pls. 33 and 18). Here we have distinct evidence of advance since 1892, when Sir Martin Conway, on his way from Sat to Bulchi, passed through " narrows, between the ice of the glacier's snout and the angle of the Gargo valley."[1] The total advance, however, is not great and may have no significance as regards truly secular movement, for the glacier is said to undergo periodic fluctuation, going through a definite cycle extending over a period of six years, three of advance and three of retreat; this characteristic is vouched for positively by the natives of Phanpher, Bulchi and Sat, who all seem to be aware not only of the movement but also of its regularity. Some reservation in accepting this statement must be made on account of the vague ideas of time-intervals entertained by most primitive communities, and the peasants in these valleys are no exception to the general rule; but there is daily intercourse throughout the greater part of the year between Bulchi and Chira on the one side and Sat and Dar on the other, and observations relative to movements of the ice which are of sufficient importance to affect the position of the path between these villages may be accepted with some confidence.

At the time of my visit (September 30th—October 4th) the snout of the main branch was said to be at its position of maximum advance, and the position of furthest retreat was reported to coincide approximately with the dotted line shown on the sketch-map (Pl. 33): this points to a fluctuation of over 300 yards in three years. I am inclined to think, however, that this superior limit has been placed too far back, since at the time of Conway's visit—May 1892, corresponding to an intermediate stage in the period of advance—the ice was evidently not far from the cliffs of the Gasunar spur; the path apparently ran at that time along the valley bottom, but the stream from Sat passed, as at present, through a tunnel under the ice near the cliffs, and although the advancing glacier might no doubt carry the tunnel forward with it, yet when the period of retreat set in the tunnel must either disappear or the stream must cut it back laterally sufficiently rapidly to keep pace with the retreat of the ice; it seems much more probable, however, that if the retreat were as great as stated the tunnel would disappear and the stream pass round the snout of the glacier. The evidence,

[1] Climbing and Exploration in the Karakoram Himalayas, 1894, p. 206.

therefore, points to a considerable vertical, but relatively small horizontal, diminution of the glacier. The wall of ice now abutting against the Gasunar cliff appears to be over 100 feet high; in the periods of retreat this must melt completely to the level of the valley and retire from the cliffs to a sufficient distance to admit of a clear passage between them and the tunnel. This might no doubt be due to seasonal or rather periodic variation in the snowfall, but such variation is not likely to be regular.

Only the main stream of the glacier appears to be affected by this periodic fluctuation, the position of the small left branch being approximately stationary. This latter branch is completely surrounded with old terminal moraine, now overgrown with scrub, and there is ample evidence that this part of the glacier has retreated. In the main valley, on the other hand, the evidence of comparatively recent retreat is by no means so well-marked: low ridges of old moraine run down the valley, but they are relatively small and have been to a great extent re-arranged by water, whilst the presence of bushes right up to the ice of the snout shows that it is some time since the glacier occupied a position in advance of its present one.

Old lateral moraines are well-marked on both sides of the valley. In the valley below Diran there are at least three clearly defined parallel ridges of moraine, of which the outer two are partially covered with full-grown forest trees, whilst the innermost of the three has been only comparatively recently left by the ice. On the right-hand side of the valley, similar old moraines can be seen beyond the steep cliffs against which the glacier lies. It is thus clear that the glacier is contracting in volume, although there may be no actual secular retreat of the snout of the main stream.

On the accompanying sketch-map, stations (1) and (2) represent points on either side of the main valley: (1) on the right side and (2) on the left. At the time of my visit, a line joining these two points would have touched the most advanced part of the snout of the main ice-stream (see Pls. 18 and 19). At each point, a cross (×) was cut on solid rock, and marks were painted in black paint beside and around the cross (×): a list of these marks will be found on the sketch-map (Pl. 33).

A third station (3) was selected high up on the hill-side, about 1,500 feet above Chira and just above the path to Damaye, a forest grazing ground above Gasunar; from this point a good general view of the glacier is obtained (see Pl. 17): this station is also on solid rock, on which the marks were cut and painted.

A conspicuous cairn, between 4 and 5 feet in height, was built over the mark cut at each of the stations; the cairn was capped with a slab on which was painted the number and date of the station, and a cross (×) several feet in length was in most cases painted on the exposed rock-face near the cairn. The paint was similar to that used for marking the mile-stones on the Gilgit Road, and the marks will probably be found to last for some years.

Barche Glacier.

The remains of old moraines which are seen extending up the hill-sides far above the present glaciers show that at one time the whole of the upper Bagrot valley was filled with a continuous sheet of ice of which these glaciers are but the mere relics: thus the villages of Gasunar, Sat, and Dar all lie on old moraine materials. Near the Barche glacier this old moraine is covered with forest of pine, spruce and juniper of great age. The glacier now consists of two main streams, one coming from the snowy peaks above the grazing-grounds of Barche and flowing south till it meets the other stream which is derived from the snow-fields among the peaks to the east and north-east and flows past Gargo[1]; from the junction, the combined streams flow due west between vertical cliffs nearly 150 feet high of old moraine on the right hand (north) side and a high rocky ridge on the left. The snout of the glacier lies at about half a mile to the south-east of the small village of Dar and ends in a broad and boulder-strewn valley. On either side of and in front of the snout are remains of a former moraine (see 2 on Pl. 34), now sparsely studded with young pine trees: the moraine, however, is stated to be considerably older than the trees; it has been eroded and in places re-arranged by water; this effect as well as the absence of older trees is said to be due to floods which occur in this valley from time to time owing to the bursting of glacial dams; a particularly violent one is said to have taken place some few years ago and to have destroyed all the trees on the moraine. Small lateral moraines, however, on either side of the snout show that there has been a comparatively recent retreat of the

[1] These are shown on Conway's map as the Burche and Gargo glaciers respectively.

ice, but it is impossible to say whether such movement is truly secular or merely seasonal.

Two large erratic blocks (A, B, Pl. 34), one on either side of the snout, were chosen as stations: a line joining these, as will be seen from the sketch-map (Pl. 34), would pass in front of the ice-cave and cut through the left toe of the glacier at 100 feet behind its extreme western end. Photographs were taken looking across the snout in each direction (Pls. 21 and 22), and a general view of the glacier (Pl. 20) was taken from a large boulder in the broad river-bed at some distance below the snout. In each case a cross (×) was cut on the rock and name of station and date of observation were painted beside it: cairns were then built over the marks and capped with slabs: the marks at the respective stations A, B and C will be found on the plan (Pl. 34). In case a marked advance of the ice should take place resulting in the obliteration of these stations, two other points were chosen, in the same straight line as A and B; these were E, a pine-tree on the edge of the precipitous cliff of old moraine, and D a flat surface of rock 47 feet 8 inches to the south of A. The trunk of the pine-tree E was blazed on the side overlooking the glacier, a cross (×) was cut into it and an inscription painted on it.

NAGIR.

Minapin Glacier.

The Minapin glacier rises in the névés on the north-east flanks of Dumani (Rakipushi)[1] and falls rapidly towards the Hunza river; near the snout is an ice-fall, marked by broken and impassable sérac; here the glacier bends almost through a right angle and terminates in a steep snout filling a narrow valley and just visible from the bridge crossing the stream between the villages of Pisan and Minapin (see Pls. 35 and 23).

From the village of Minapin the lower part of the glacier is hidden by steep hills composed partly of solid rock and partly of old moraine The rock consists of garnetiferous sandy mica schist and crystalline limestone; its face is very steep and has been beautifully polished and grooved by ice, thus showing that at one time there was a steep ice-fall from the top of the ridge down to the valley below.

[1] The name "Rakipushi" is only known in Hunza and Nagir as the name applied by Europeans to the peak locally called "Dumani."

Evidence of retreat of the ice is afforded not only by the glaciated rock-surfaces, but also by two old moraines, one of which (1, Pl. 35) now forms an old grass-covered ridge some way from the present glacier. The second moraine (2, Pl. 35) is of the nature of a terminal moraine and is of comparatively recent date, having been left by the ice as it gradually shrank back off the limestone cliffs and became restricted to the narrow gorge in which it now flows. There is no well-marked terminal moraine in the stream-bed in front of the snout; this may be due to the fact that the glacier is now advancing, but is more probably attributable to the fact that any material dropped from the snout is at once distributed by the violent stream which issues from the ice-cave and, during the summer, completely fills the narrow gorge to which the snout is now confined.

According to local tradition, the glacier, five generations ago, extended almost down to the bridge, and even after making due allowance for the unreliability of local conceptions of time-intervals, it is evident that the total amount of retreat of the glacier in historical times must have been very appreciable.

For purposes of observation, two points were chosen—one on either side of the gorge—in such positions that a line joining the two touched the present snout of the glacier: these points are B and D on the plan (Pl. 35). At B, a cross (×) was cut on a large block, and the letters G. S. I. and date (24th September 1906) were painted on the face of the rock; over this a cairn was built. On the opposite, left bank, of the gorge, a cross (×) was also cut in the solid rock beside the path leading to the summer grazing grounds, and the usual marks were painted on the rock-face. On the same side of the gorge and immediately above the cliff of old moraine overhanging the stream, a rock (A) was chosen and a cairn built over it; from this point the photograph (Pl. 24) was taken of the snout of the glacier.

Plate 23 shows the snout of the glacier as seen from a large flat rock situated at 150 feet to N. 20° E. of the bridge on the main road from Pisan to Minapin and 20 feet S. 10° W. from the nearest point of the road; this station offers considerable facility for observation of the movements of the glacier, for subsequent photographs taken from the same point should offer evidence of advance or retreat.

The marks and cairns were shown to the headman of Minapin village, who was instructed to keep them in repair.

Hispar Glacier.

The Hispar glacier, which is one of the largest in the Himalayan region, has a length of about 25 miles and a breadth near its snout of nearly ¾ mile. It occupies a long trough, which is parallel to the strike of the stratified rocks, and is a typical example of the longitudinal type of glacier referred to below (p. 136). The snout of the glacier lies at about 1½ mile from the village of Hispar.

The glacier was visited in 1892 by Sir M. Conway, who came to the conclusion that it had for a long time been practically stationary.[1] At the time of his visit, the path crossing the snout of the glacier to the grazing grounds of Bitermal left the left bank at some little distance below the loop-holed wall ("sangar") built across the path to Chokutens (3, Pls. 36 and 27). This sangar is still in a very good state of preservation, and serves as an admirable landmark, but the path across the glacier no longer takes off below, but at about 100 yards above, the sangar; it is evident, therefore, that, at the time of Conway's visit, the ice extended to some little distance further down the valley than in September 1906. The total retreat is only a matter of a few hundred yards, and might quite well be due to seasonal variation. Evidence of retreat in comparatively recent times, however, is afforded by a single narrow moraine (b, Pl. 36) extending for some distance down the valley from the right toe of the glacier: this moraine is narrow and only about 30 feet in height, but is fairly continuous up to the glacier (Pl. 25).

In order to determine the movement of the glacier, four stations were chosen; *viz.*, A, a large erratic block near the edge of the steep cliff on the left bank of the river and at a little over a mile from the snout of the glacier and about 800 yards from the village of Hispar. From this a photograph (Pl. 25) was taken giving a general view of the glacier. A cross (×) was cut in the stone, the date (17th September 1906) added in black paint, and a cairn was then built over the marks.

The next point is a steep and conspicuous hill of old moraine (B, Pl. 36) on the left side of the valley: from this a photograph (Pl. 26) of the snout and ice-cave was taken and the site was marked by means of a cross (×) cut on a block of white crystalline limestone on the top of the hill: this was also marked with a circle ○ and a large

[1] *Op. cit.*, p. 331.

cross (×) in black paint, and a cairn was built over the marks. The camera was set up at eight feet to north-west of this mark.

The next station selected (C) is a granite block on the old lateral moraine on the right side of the glacier: on this the usual cross (×) was cut and the date (16th September 1906) painted on the stone; a cairn was then built over the mark and capped by a flat stone similarly painted. From this point a photograph (Pl. 27) was taken looking towards the "sangar"(3) on the left side of the valley. The line joining the points (C) and (3) just touches the right toe of the glacier and cuts the left toe 350 feet behind its extreme point.

Yengutsa Glacier.

Between the villages of Hispar and Darapu a deep and narrow valley[1] is now occupied by a glacier, the snout of which abuts on the fields on either side. This and the glacier to be next described are in many respects the most interesting of those visited, for both are known to have advanced with startling rapidity in the course of the last few years.

In the year 1892, the path from the fields of Darapu to Hispar village descended into a precipitous gorge: "a deep nala . . . divides Darapu from Hispar. In its bowels some half-dozen mills find a footing. The path goes round by these and mounts to the fairer fields of Hispar."[2]

It is difficult to imagine a more striking contrast than that between the picture called up by Conway's description of the ravine and its present condition. Now the path, instead of descending, climbs arduously over a steep mass of black and slippery ice, the mills are gone and their ruins hidden under the snout of the advancing glacier, and many of the "fair fields" are now an uncultivated waste of boulder and moraine (see Pl. 37): what the total amount of advance has been it is not possible to say, but to judge from Sir Martin Conway's map, it must have been at least two miles. Nor does this appear to have been gradual, for according to local reports, the glacier moved forward suddenly some five years ago, and has since been practically stationary.

[1] On Sir M. Conway's map the glacier is named the Rung Pa, but the name locally used at the time of my visit was Yengutsa.

[2] *Op. cit.*, p. 325.

Pl. 28 shows a general view of the glacier taken from a large erratic block of granite (D) lying in a field to the east-south-east of Hispar village; this block was marked in the usual way and a cairn was built over the mark.

Two stations were also chosen, one on either side of the snout of the glacier, in such position that a line joining the two would touch the extreme snout of the ice in the valley-bottom. That on the Hispar side is a large flat stone at the south-east corner of the cemetery; this was marked with the usual cross (×) cut on the stone and the letters $\frac{D}{e}$ were added in black paint; similarly, the station on the Darapu side is a large boulder of granite, which was marked $\frac{D}{w}$. Pl. 29 represents a photograph taken from this latter station, looking up the Yengutsa valley, whilst Pl. 30 is a view of the snout and ice cave taken from the edge of the precipitous bank 40 feet to E. 20° S. of $\frac{D}{w}$. Cairns were built over each of these stations, and these, as well as the cairns at stations A, B and C of the Hispar glacier, are put in charge of the village headman (Gauhar by name) and a member of the local levy, named Shah Murad, who had accompanied Sir M. Conway in 1892.

HUNZA.

Hassanabad Glacier.

Like the Yengutsa glacier, that of Hassanabad has a well-authenticated history of recent advance, but in this case the advance has been much greater than in the case of the Yengutsa glacier. According to the statements of the Mir of Hunza and his Wazir, the advance took place about three years ago, when the glacier moved forward over a distance, variously estimated as from six miles to one day's march, in the course of 2½ months; owing to the danger involved to the villages in the valley, its progress was very carefully watched, and the above statements may therefore be regarded as reliable, although undoubtedly somewhat indefinite. The snout is now said to be stationary, no further advance having been recently observed. It is further stated by the Wazir that the glacier occupied its present position many years ago; it subsequently retreated very rapidly, but has now returned to its former site. The snout lies in a broad gravelly stream-bed (see Pl. 38) with no trace of recent moraine, either terminal or lateral. Three points were selected as stations, one being on either side of the snout and a third (3) on a large flat rock near the last (most northerly) group of bushes growing beside the Garukin irrigation-channel, high up on the steep slope on the right side of the valley.

Station (1) is a large erratic block of granite just above the right bank of the river, the point chosen on the opposite bank is a conspicuous cliff with intersecting veins of white granite ; the photograph of the snout (Pl. 31) was taken from station (1) looking towards station (2). A line joining stations (1) and (2) would just touch the toe of the glacier.

Plate 32 is a general view or the glacier taken from station (3) on the Gamkin irrigation-channel.

SUMMARY.

Six glaciers in Hunza, Nagir and Bagrot have been visited and sketch-maps and photographs of their snouts prepared with a view to determine the direction and amount of their secular movements. These glaciers are the Hinarche and Barche in the Bagrot valley, the Minapin, Hispar, and Yengutsa in Nagir, and the Hassanabad glacier in Hunza.

The glaciers fall into two classes, *viz.*, those which lie in troughs parallel to the mountain-ranges, and those which flow at right angles to the ranges: the former may be termed longitudinal and the latter transverse glaciers. Of those enumerated above, the majority, *viz.*, the Hinarche, Minapin, Yengutsa, and Hassanabad glaciers, are transverse ; the Hispar is a very typical longitudinal glacier; whilst the Barche glacier is in the main longitudinal, but one of its branches, the smaller of the two, is transverse. The longitudinal glaciers are characterised by their greater length, greater stability, gentler gradient and the higher elevation at which they terminate (about 10,000 feet as compared with elevations of less than 8;000 feet to which such glaciers as those of Minapin and Hassanabad descend). The longitudinal glaciers are therefore likely to give more reliable evidence as to the direction of truly secular movements than are the transverse glaciers, which appear to be more readily affected by seasonal and short-period variations. Thus the Hispar and Barche glaciers show no signs of rapid fluctuation, such as has affected those

of Hinarche, Yengutsa, and Hassanabad; they appear, on the other hand, to be almost stationary, with, however, a general tendency to retreat. Of the transverse glaciers, two, the Yengutsa and Hassanabad, have advanced remarkably in recent years; the Hinarche appears to fluctuate, advancing and retreating through short periods, although the numerous lateral moraines point to a general history of retreat, whilst the history of the Minapin glacier appears to be one of steady secular retreat.

(*Notes on Lahaul and Kumaon will be issued in Part 4.*)

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LIST OF PLATES, VOLUME XXXV.

L. L. Fermor.

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Three views of the largest fragment (240. A. 1) of the Meteoric Fall of October 22nd, 1903, at Dokáchi and neighbourhood, Dacca District, Bengal. This piece fell in Dokáchi itself.

Photo by E. Vredenburg.

Bemrose, Collo., Derby.

1 2 3 4 5 6 7 8 9 10 C. M.

240. A. 2.—DOKÁCHI.—TWO VIEWS.

240. A. 3.—DOKÁCHI.—THREE VIEWS.

240. B.—KOLAPÁRA.—TWO VIEWS.

2 3 4 5 6 7 8 9 10 C. M.

Photo. by E. Vredenburg. *Bemrose. Collo., Derby.*

3 STONES FROM THE METEORIC FALL OF DOKÁCHI, DACCA DISTRICT. BENGAL.

L. L. Fermor.

Records, Vol. XXXV, Pl. 3

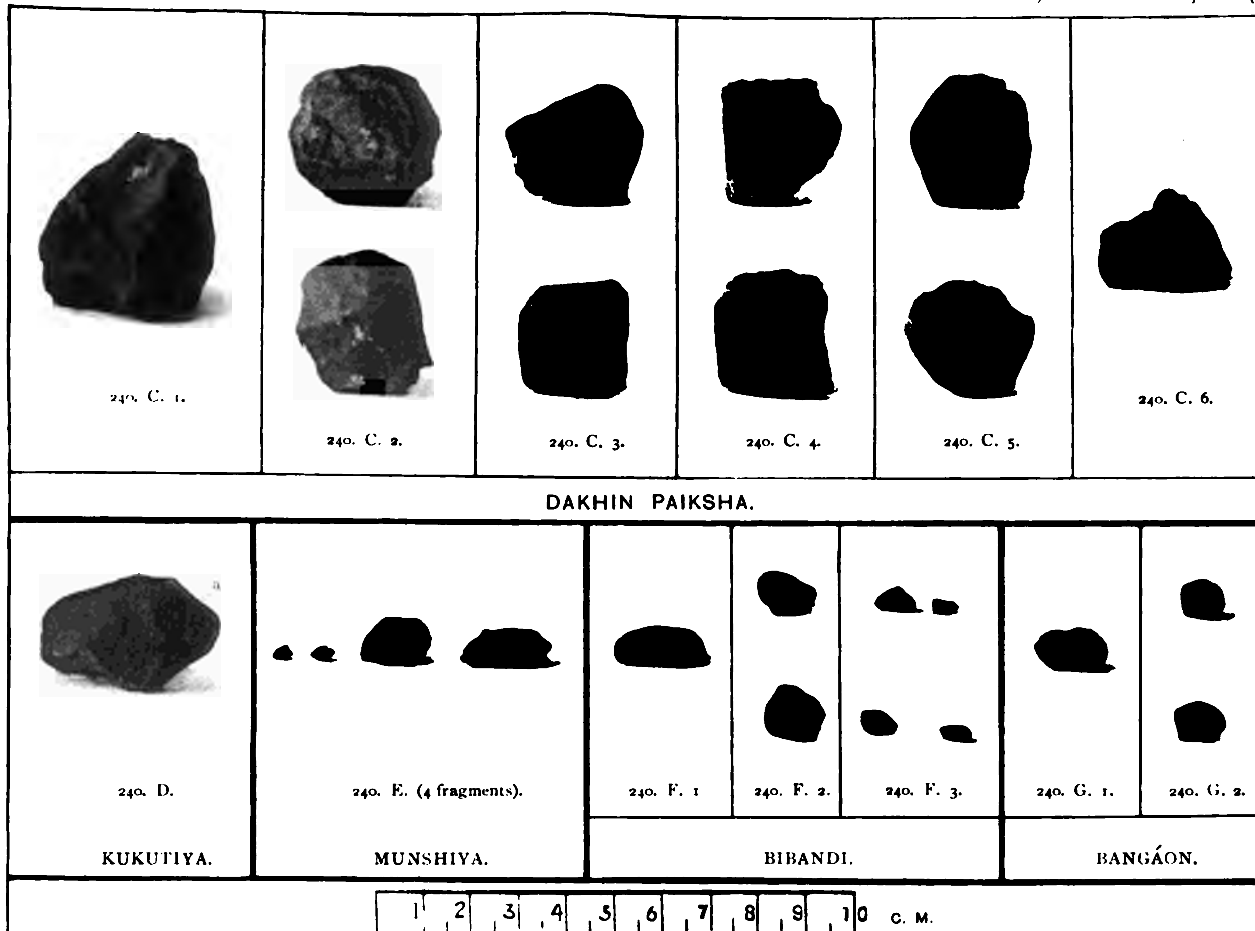


Photo by E. Vredenburg.

Bemrose, Collo., Derby.

13 STONES FROM THE METEORIC FALL OF DOKÁCHI, DACCA DISTRICT, BENGAL.

H. B. W. Garrick, Photo. Fig. 1.

H. B. W. Garrick, Photo. Fig. 2. *Bemrose. Collo., Derby.*

THE BHOLGHATI METEORITE (NO. 241).

Fig. 1 –Front view showing the face A—Natural Size.

Fig. 2—The fractured part of Fig. 1—(Slightly enlarged, and exposed so as to show the white spots).

H. B. W. Garrick, Photo. Bemrose, Collo., Derby.

THE BHOLGHATI METEORITE (NO. 241).

View showing the face C and a little of B (on the right).—Natural Size.

H. B. W. Garrick, Photo. *Bemrose, Collo., Derby.*

THE BHOLGHATI METEORITE (NO. 241).

Inverted; shows the face B and the base of the tetrahedron.—Natural Size.

H. B. W. Garrick, Photo. Bemrose, Collo., Derby.

THE BHOLGHÁTI METEORITE (NO. 241 B).

Front view. Natural size.

H. B. W. Garrick, Photo. Bemrose, Collo., Derby.

THE BHOLGHÁTI METEORITE (NO. 241 B).

End view of meteorite resting on its front face. Natural size.

L. L. Fermor. Records, Vol. XXXV, Pl. 9

H. B. W. Garrick, Photo. *Bemrose, Collo., Derby*

THE KARKH METEORITE (NO. 239 A). LARGE PIECE. HALF NATURAL SIZE.

L. L. Fermor. Records, Vol. XXXV, Pl. 10

H. B. W. Garrick, Photo. *Bemrose, Collo., Derby.*

THE KARKH METEORITE (NO. 239 A).

View of part of large piece showing pittings and flow-markings of crust. Natural Size.

H. B. W. Garrick, Photo. *Bemrose, Collo., Derby*

THE KARKH METEORITE (NO 239 A).

Large piece. View from left hand end. Half Natural Size.

H. B. W. Garrick, Photo. Fig. 1

H. B. W. Garrick, Photo. Fig. 2. *Bemrose, Collo., Derby.*

THE KARKH METEORITE (NO. 239 B). SMALL PIECE. HALF NATURAL SIZE.

Fig. 1—Front view showing pittings. Fig. 2— View from above showing thickness of crust.

H. B. W. Garrick, Photo. *Bemrose, Collo., Derby.*

THE HARAIYA METEORITE (NO. 237). FRONT VIEW. NATURAL SIZE.

Shows pittings and radiated flow-lines of crust.

H. B. W. Garrick, Photo. Bemrose, Collo., Derby.

THE HARAIYA METEORITE (NO. 237). BACK VIEW. NATURAL SIZE.

Shows radiating flow-lines of crust.

H. B. W. Garrick, Photo *Bemrose, Collo., Derby.*

THE HARAIYA METEORITE (NO. 237). THREE-QUARTER VIEW OF FRONT SIDE. NATURAL SIZE.

Shows radiating flow-lines of crust.

Fig. 1 Sketch of Furnace with pans removed.

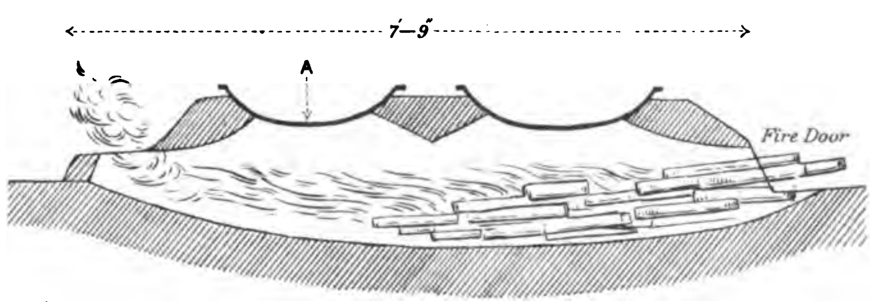


Fig. 2 Longitudinal Section.

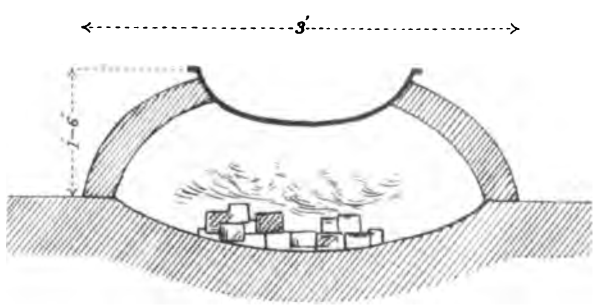


Fig. 3 Cross Section at A, fig. 2.

Drawn by T. H. D. La Touche.

SALT-BOILING FURNACE. BAWGYO.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HINARCHE GLACIER.

From Station 3.

[For index to letters, see sketch map of Glacier.]

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HINARCHE GLACIER.

Snout from Station 1.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HINARCHE GLACIER.

Snout from Station 2.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

BARCHE GLACIER.

From Station C.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

BARCHE GLACIER.

From Station A, looking towards Station B.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

BARCHE GLACIER.

From Station B, looking towards Station A.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

MINAPIN GLACIER.

General view from bridge Station.

[×, Snout of Glacier.]

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

MINAPIN GLACIER.

View of Snout from Station A.

Photo. by H. H. Hayden. Bemrose, Collo., Derby.

HISPAR GLACIER.

From Station A.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HISPAR GLACIER.
Ice-cave from Station B.
[3, Sangar.]

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HISPAR GLACIER.

Snout from Station C, looking towards Sangar (3).

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

YENGUTSA GLACIER.

From Station D.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

YENGUTSA GLACIER.

Left front from Station $\frac{D}{w}$.

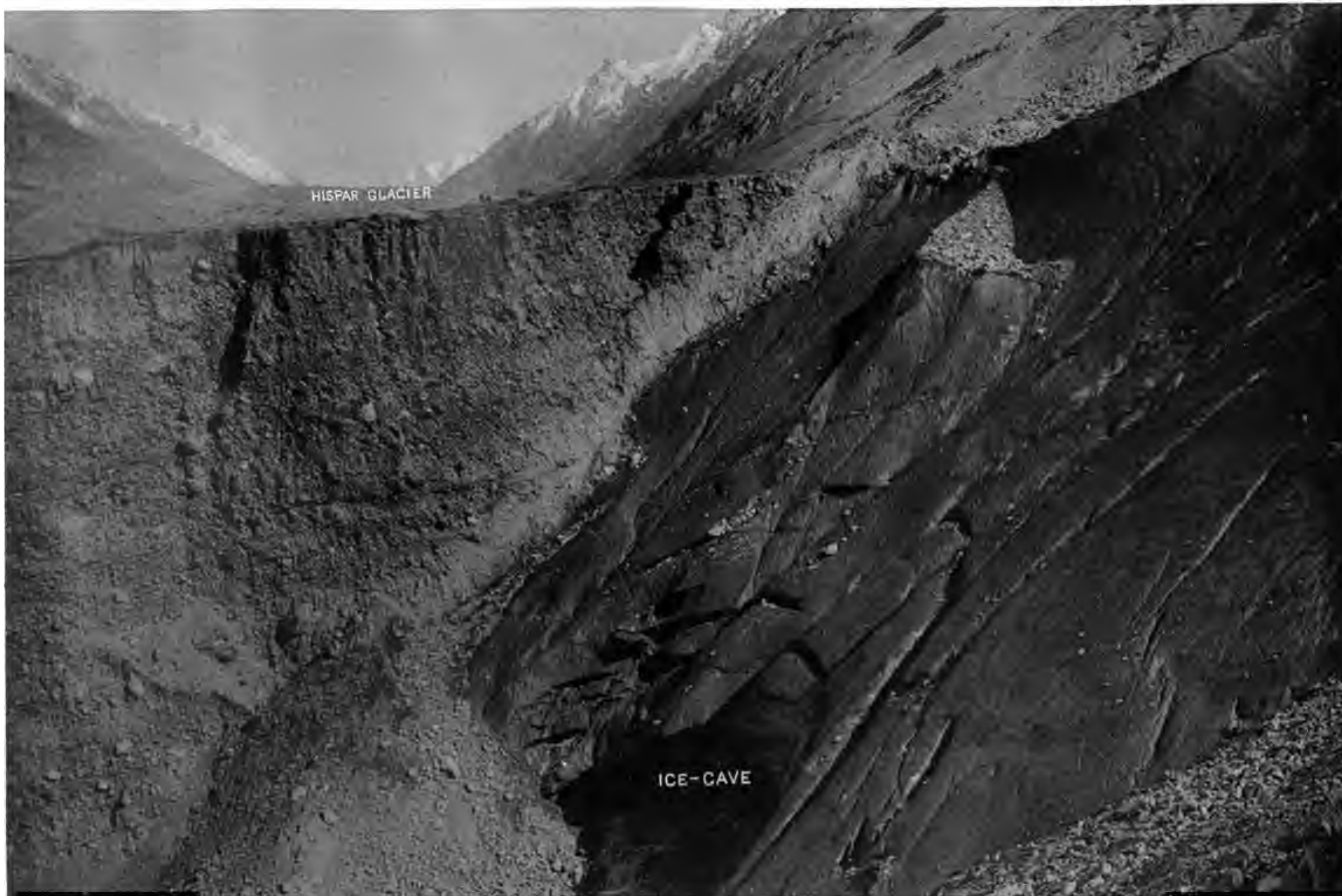


Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

YENGUTSA GLACIER.

Snout from Station $\frac{D}{w}$, looking towards $\frac{D}{c}$.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HASSANABAD GLACIER.

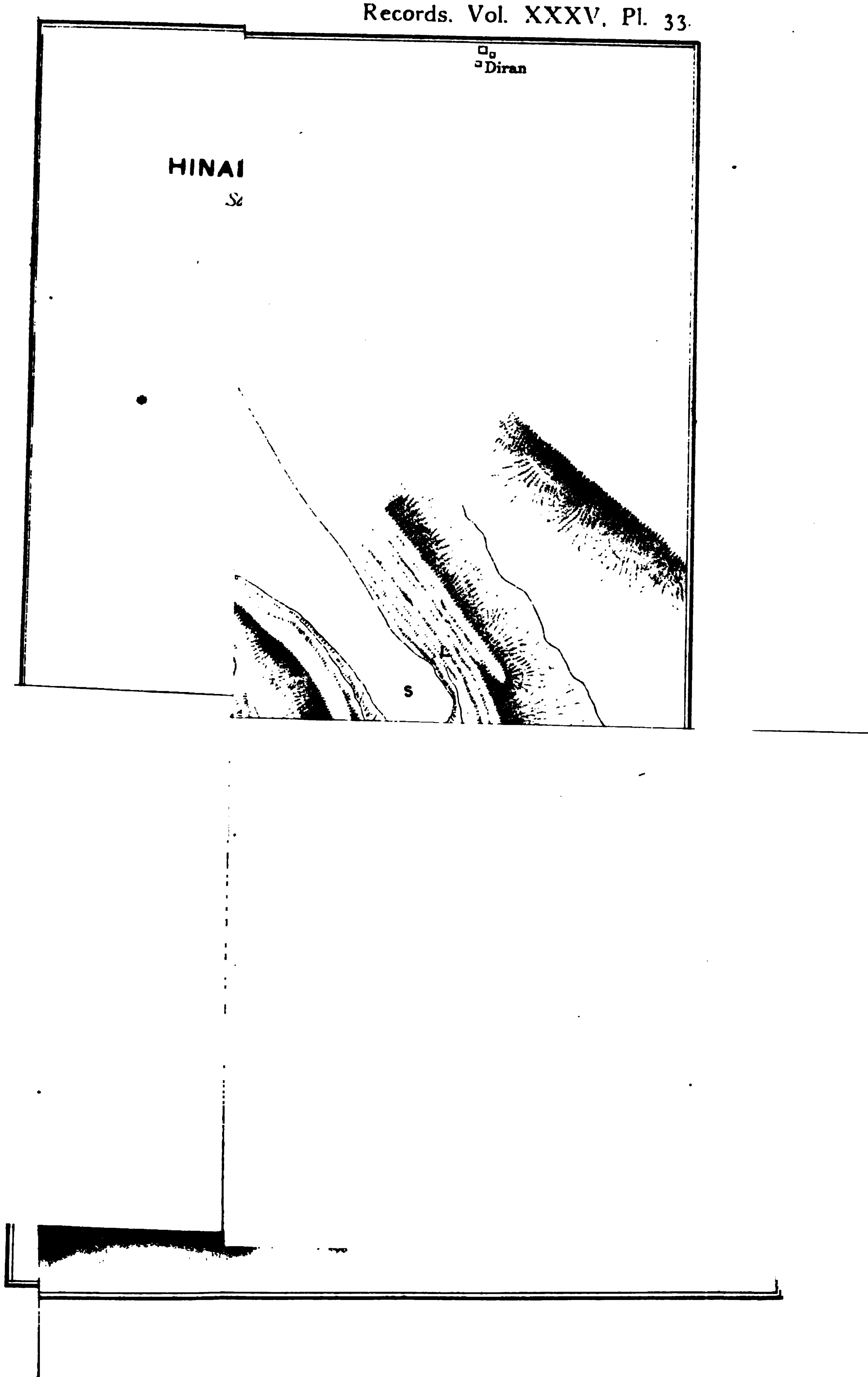
From Station 1, looking towards Station 2.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HASSANABAD GLACIER.

From Station 3.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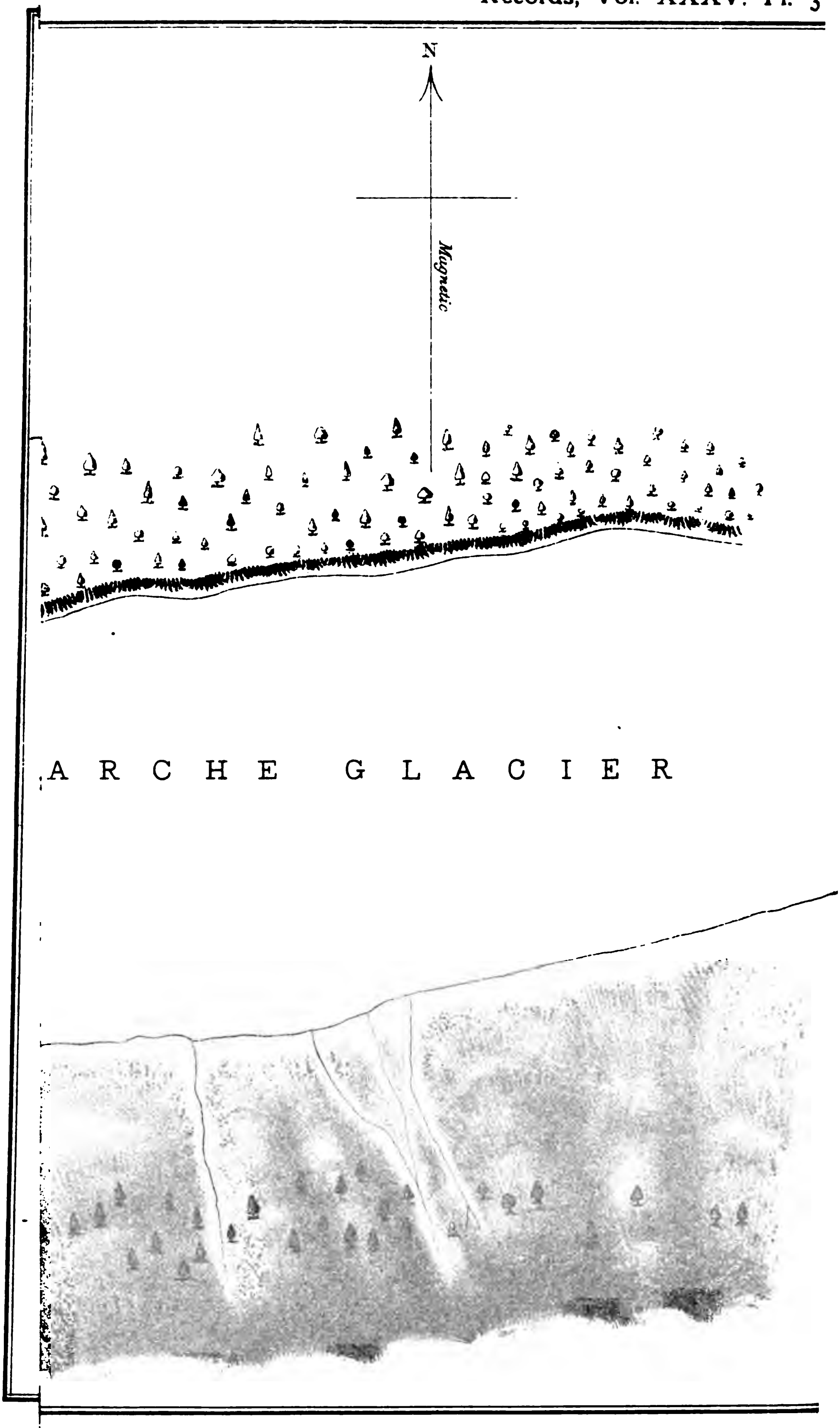
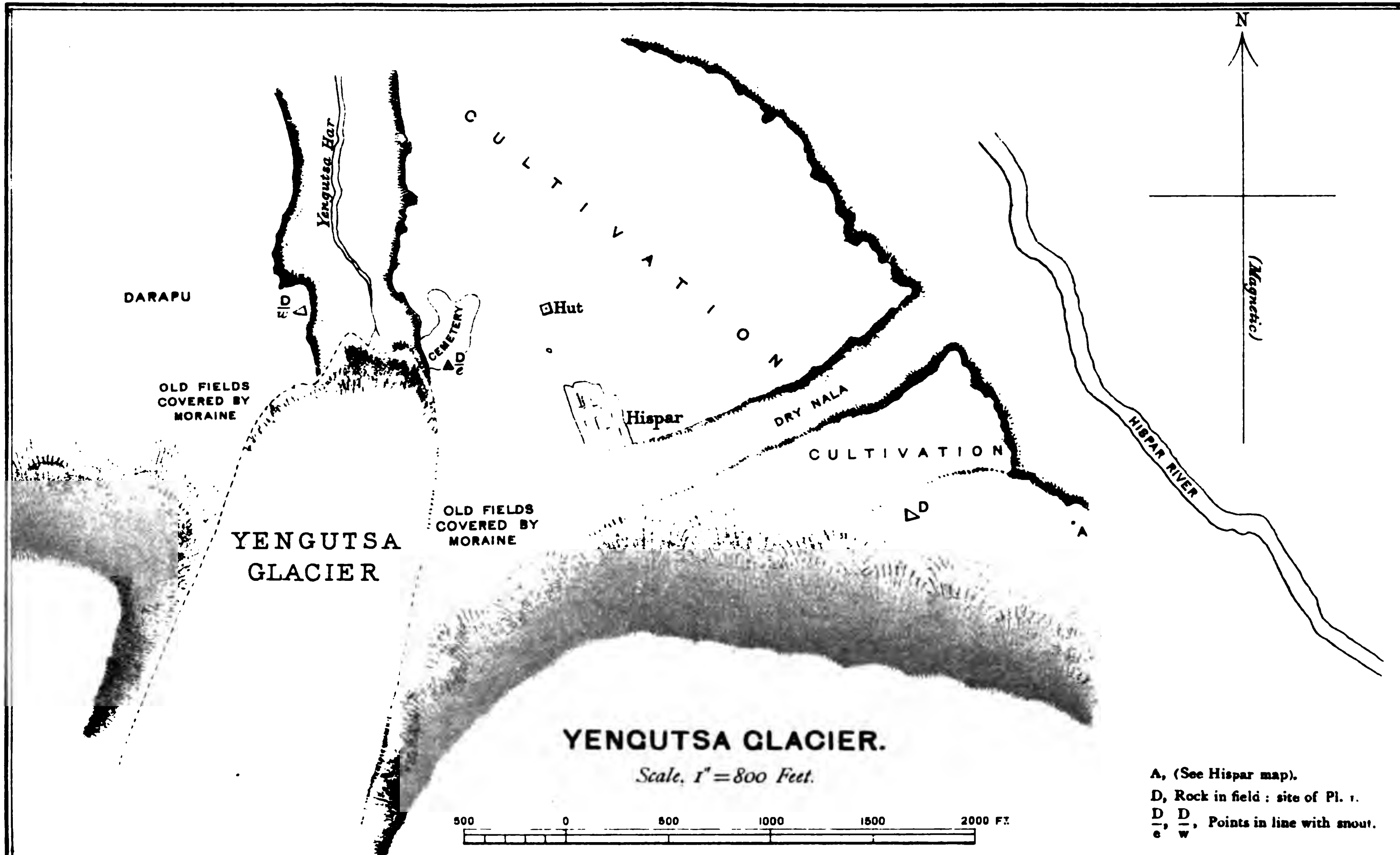

N
Magnetic
ARCHE GLACIER



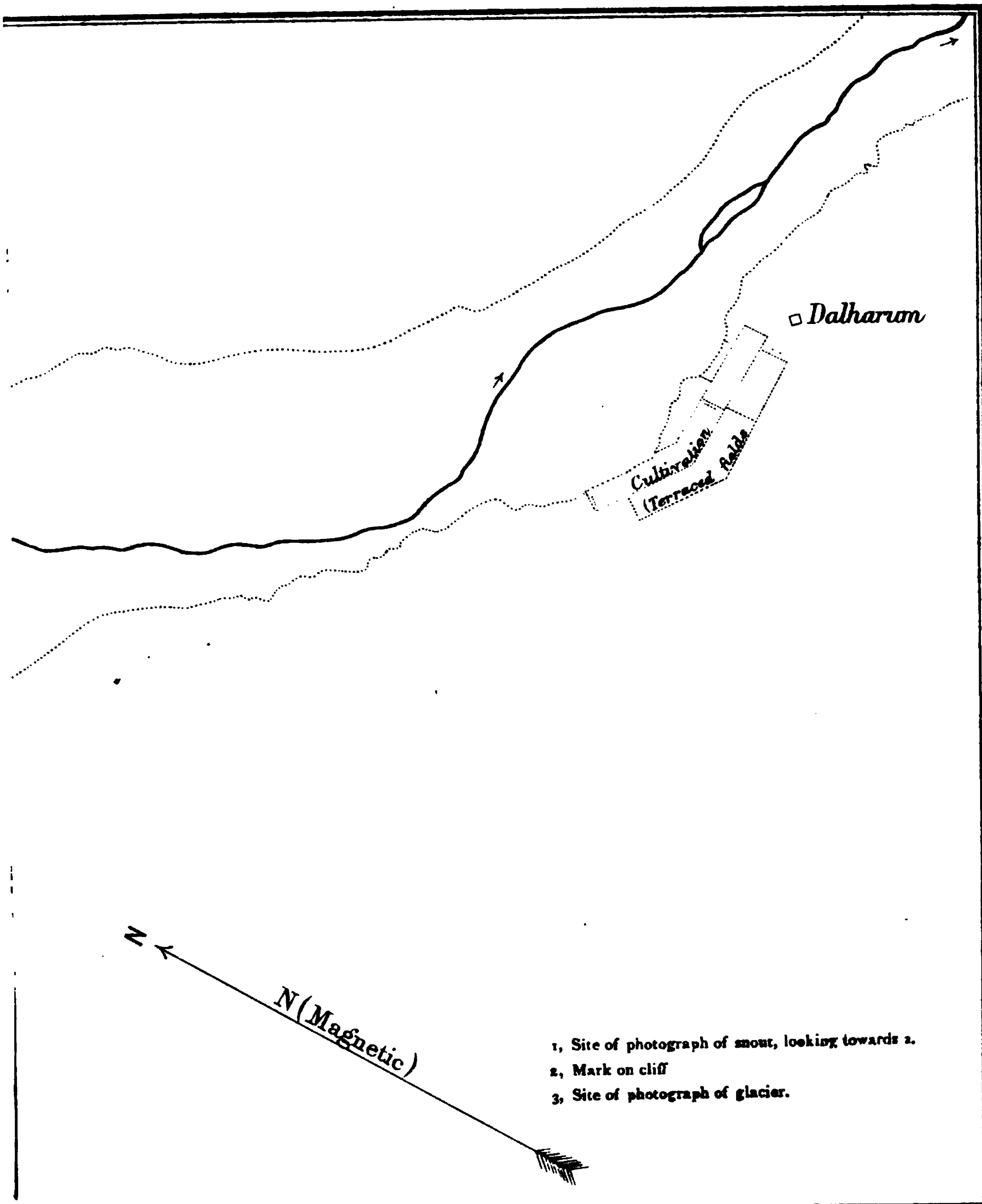
YENGUTSA GLACIER.

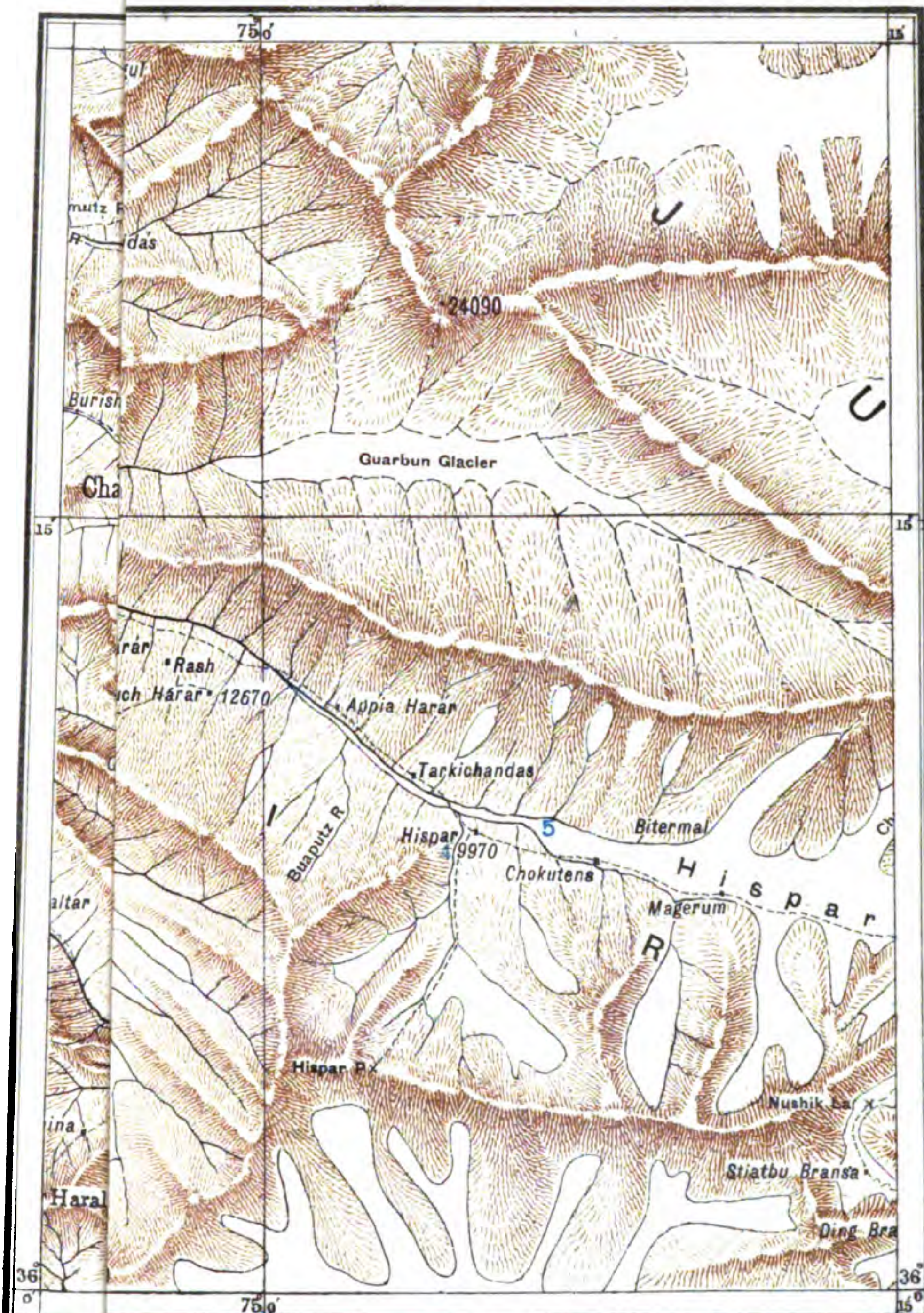
Scale, 1" = 800 Feet.

A, (See Hispar map).

D, Rock in field : site of Pl. 1.

$\frac{D}{e}$, $\frac{D}{w}$, Points in line with snout.


Dalharum
Cultivation
(Terraced fields
N(Magnetic)
N
1, Site of photograph of snout, looking towards 2.
2, Mark on cliff
3, Site of photograph of glacier.



No 90 E.,

Helio., S. I. O., Calcutta.

ND BAGROT.

Photo. by H. Walker.

Bemrose, Collo., Derby.

SONAPÁNI GLACIER, LAHAUL.

View from Station No. III.

Photo. by H. Walker.

Bemrose, Collo., Derby.

SONAPÁNI GLACIER, LAHAUL.

View from Station No. V.

Photo. by H. Walker.

Bemrose, Collo., Derby.

SONAPÁNI GLACIER, LAHAUL.

Old terminal Moraine with lake deposits in foreground.

View from Station No. VI.

Photo. by H. Walker. Bemrose, Collo., Derby.

SONAPÁNI GLACIER, LAHAUL.

Oldest terminal moraine cut through by glacier stream.

Photo. by E. H. Pascoe.

SHIGRI GLACIER, LAHAUL.

View from Station No. I.

Bemrose, Collo., Derby.

Photo. by E. H. Pascoe.

Bemrose, Collo., Derby.

SHIGRI GLACIER, LAHAUL.

View from Station No. III.

Photo. by E. H. Pascoe.

Bemrose, Collo., Derby.

SHIGRI GLACIER, LAHAUL.

View from Station No. IV.

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Photo. by G. de P. Cotter.

Bemrose, Collo., Derby.

OLD GRASS-GROWN MORAINES NEAR MARTOLI CAMPING GROUND.

Photo. by G. de P. Cotter.

ICE-CAVE, LEFT VIEW.

Bemrose, Collo., Derby.

ICE-CAVE, RIGHT VIEW.

Photo. by G. de P. Cotter. *Bemrose, Collo., Derby.*

VIEW OF PINDARI GLACIER FROM C. SHOWING SNOUT.

Photo. by G. de P. Cotter. Bemrose, Collo., Derby.

VIEW FROM D. SHOWING RIGHT AND LEFT LATERAL MORAINES WITH GLACIER BETWEEN.

Photo. by G. de P. Cotter. *Bemrose, Collo., Derby.*

VIEW FROM D. SHOWING THE UPPER GLACIER WITH MEDIAL MORAINE AND THE TWO ICE FLOWS.

Photo. by G. de P. Cotter. Bemrose, Collo., Derby.

THE VALLEY LEADING TO THE UTARDHURA PASS BLOCKED UP BY MORAINE FROM THE MILAM GLACIER. TAKEN FROM MILAM.

Bemrose, Collo., Derby.

MILAM GLACIER FROM A.

Photo. by G. de P. Cotter.

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Photo. by G. de P. Cotter.

MILAM GLACIER FROM B.

Bemrose, Collo., Derby.

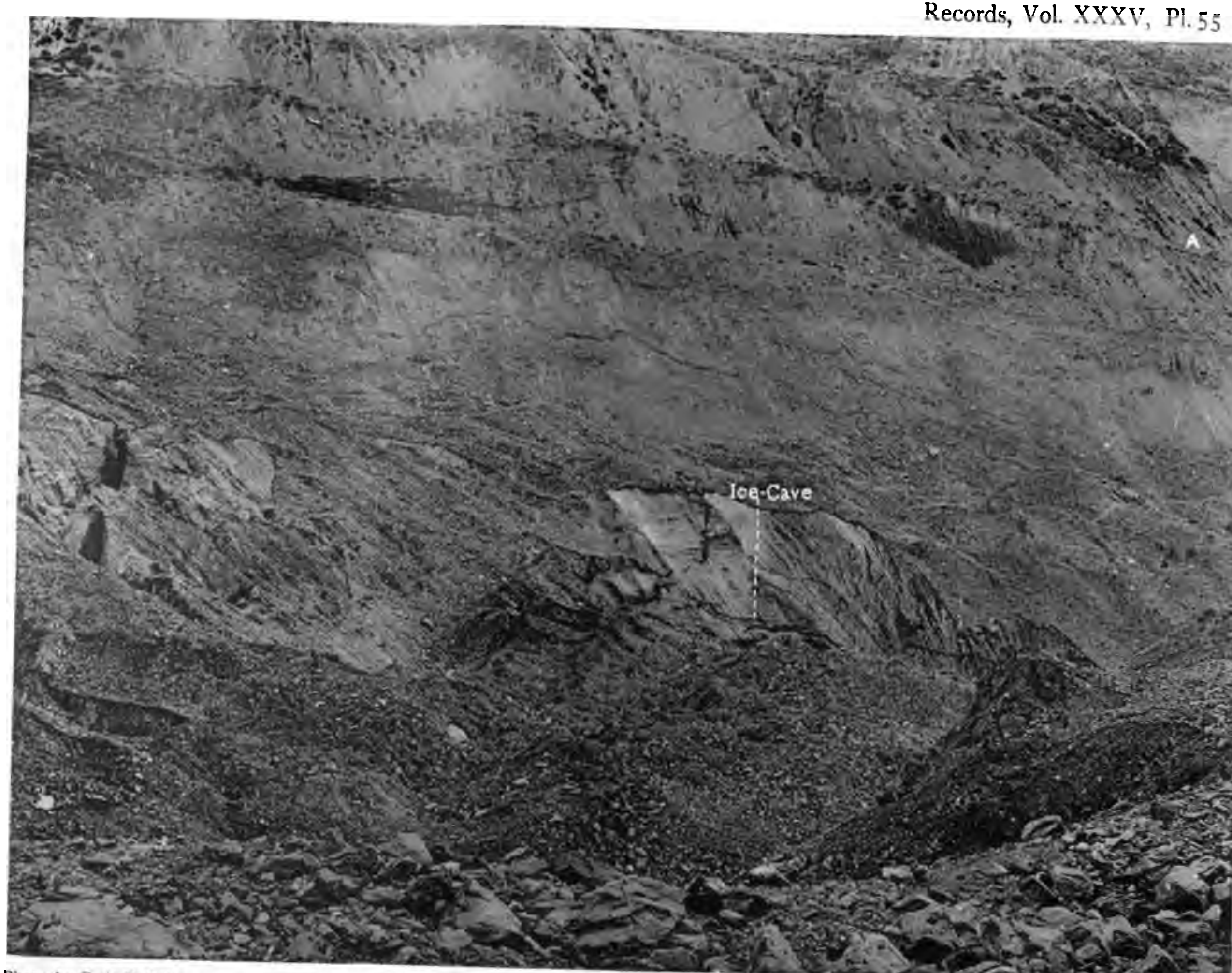

Photo. by G. de P. Cotter.

MILAM GLACIER AND ICE-CAVE FROM C.

Bemrose, Collo., Derby.

Photo. by G. de P. Cotter.

SHANKALPA GLACIER AND ICE-CAVE FROM A., SHOWING GLACIATED ROCK.

Bemrose, Collo., Derby.

Photo. by J. C. Brown. Bemrose, Collo., Derby.

SHANKALPA GLACIER AND ICE-CAVE FROM B.

Photo. by J. C. Brown. Bemrose, Collo., Derby.

POTING GLACIER AND ICE-CAVE, WITH SNOWY RANGES IN BACKGROUND. TAKEN FROM CAMPING GROUND.

Photo. by G. de P. Cotter.

POTING GLACIER FROM C.

Bemrose, Collo., Derby.

6d

V, Pl. 64

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